Resistance-training experience and the pressor response during resistance exercise

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FLECK, STEVEN J., AND LARRY S. DEAN. Resistance-training experience and the pressor response during resistance exercise. J. Appl. Physiol. 63(1): 116–120, 1987.—The purpose of this study was to examine the effects of previous resistance-training experience on the cardiovascular responses to resistance-training exercises. To investigate this, the intra-arterial blood pressure response of four body builders (BB), six novice weight-trained individuals (NT), and six sedentary controls (SC) were monitored during performance of one-arm overhead presses and one-leg knee extensions. One repetition at the maximal weight possible (1 RM) and rest to peak fatigue at 90, 80, 70, and 50% of 1 HM were performed. Across groups, the BB demonstrated the significantly (P < 0.05) lower peak and a lesser magnitude of response (changes from rest to peak) for systolic and diastolic blood pressures than the the NT and SC groups during both exercises. The BB also demonstrated significantly lower values across groups for peak heart rate and magnitude of heart rate response during arm presses. During knee extensions across groups, peak heart rate but not magnitude of the heart rate response was significantly lower in the BB. The results indicate that previous weight-training experience reduces the pressor response to dynamic resistance exercises.

METHODS

Four experienced male body builders, six novice resistance-trained males, and six males with no prior resistance-training experience served as subjects. Morphological data of the three groups are presented in Table 1. The body builders were all competing and had been consistently training (2 h/training session, 6 days/wk for 2–8 yr). The novice resistance-trained group had been training for 6–9 mo utilizing Nautilus equipment and training protocol. They performed 2–3 circuits of 10–12 exercises, with each set consisting of 8–12 repetitions. The nonexperienced resistance-trained group had never consistently performed physical training. All subjects were informed of the potential risks of the experimental procedure in accordance with the institution's human subjects research committee. Written consent of all subjects was obtained and subjects were informed they could withdraw from the project at any time.

Before the experimental procedure, an Allen’s test was performed on the nondominant arm of all subjects. Briefly, an Allen’s test consists of the examiner applying pressure with his fingers to occlude blood flow in the subject’s radial artery. The examiner then palpates the pulse in the ulnar artery of the subject. The examiner makes a subjective evaluation as to whether the pulse and, therefore, blood flow in the ulnar artery could adequately perfuse the hand if the radial artery were permanently occluded. This test was performed to ensure the safety of the subjects. The anterior distal forearm surface of the nondominant arm was bathed in an iodine solution. Then following administration of a subcuta-
neous local anesthetic (1% Litocaine), the radial artery of the nondominant arm of the subject was cannulated utilizing a 20 gauge angiocath. A standard intra-arterial blood pressure monitoring kit (Sorenson, model MK3-03NVF, Sorenson Research, Salt Lake City, UT) and pressure transducer (Statham P23 ID) were utilized to connect the angiocath to a polygraph (Grass Instrument, Quincy, MA). The entire blood pressure monitoring system was statically calibrated against a mercury manometer and verified to be linear between 0 and 300 mmHg. Height of the pressure transducer was adjusted to the fourth intercostal space for each exercise and blood pressure monitored continually during the experimental protocol. Heart rate was determined from the blood pressure tracings.

The weight-training exercises performed were one-arm overhead presses and one-leg knee extensions. Both exercises were performed with the dominant limb. One-arm overhead presses were performed with free weights and knee extensions with Universal gym equipment. Sets at 100, 90, 80, 70, and 50% of the maximal resistance that could be utilized for one complete repetition (1 RM) were performed. The 100% set was performed first followed by the other four sets in random order. The 1 RM of each subject for both lifts was determined 2–3 days before the performance of the experimental procedure. All sets were performed to the point of voluntary fatigue with a 3-min rest between each successive set. Peak pressures and heart rate were determined during all sets. Which repetition of a set or which phase of a repetition (i.e., concentric or eccentric) peak values for these measures occurred during was not considered.

To minimize the effect of confounding factors influencing the pressor response, several precautions were taken. The subjects were instructed to inhale and exhale continuously during the concentric and eccentric portion of each repetition, respectively. This was done to minimize the performance of a Valsalva maneuver. Sets in which continuous inhalation and exhalation did not occur were repeated. Both exercises were performed in a seated position and no grasping of the seat with either hand was allowed. A strap passing over the thighs to stabilize the subjects was utilized during performance of the knee extensions.

Analysis of variance (ANOVA) techniques were utilized to determine whether significant differences were present. Three by five completely randomized ANOVA’s were utilized in analysis of all variables for differences among groups and among sets at the various percent of 1 RM. Two by five repeated measured ANOVA’s were utilized in analysis of all variables for differences between the arm press and knee extension exercises in each group of subjects. The Scheffé analytical procedure was the post hoc test used where appropriate. The 0.05 level of significance was utilized in all statistical procedures.

RESULTS

Resting heart rate and resting systolic and diastolic blood pressures were not different (P < 0.05) among any of the groups. In all cases, peak heart rate and blood pressures were demonstrated during the last 1–3 repetitions of a set. Peak and magnitude of response (change from rest to peak values) for both heart rate and blood pressures were not different (P > 0.05) between knee extensions and arm presses.

Sixteen percent of the pressure tracings showed indications of performance of a Valsalva maneuver after cessation of the set. Seventy-seven percent of the pressure tracings that showed indications of performance of a Valsalva maneuver occurred during 1 RM or 90% sets. The indications of a Valsalva were evenly distributed among groups and arm vs. leg exercise.

Across groups, peak systolic and diastolic blood pressures during knee extensions and one-armed overhead presses were significantly greater (P < 0.05) in the control and novice groups than the body builders (Figs. 1 and 2). During knee extensions, peak systolic and diastolic pressures across treatments (percent of 1 RM) demonstrated significantly greater (P < 0.05) values at 80, 70, and 50% and 80 and 70% of 1 RM than at 1 RM, respectively (Fig. 1).

Magnitude (i.e., peak value minus resting value) of the blood pressure responses demonstrated a pattern similar to that of the peak blood pressures. Across groups, the magnitude of the systolic and diastolic pressure responses were significantly greater (P < 0.05) in both exercises for the control and novice groups than the body builders. The magnitude of the systolic and diastolic pressure responses across groups during knee extensions demonstrated significantly greater (P < 0.05) values at 80, 70, and 50% of 1 RM than at 1 RM (Fig. 1).

Across groups, peak heart rate was significantly higher (P < 0.05) during both exercises for the control and novice groups than the body builders (Figs. 3 and 4). Peak heart rate across treatments demonstrated signifi-
FIG. 1. Results of peak systolic and diastolic blood pressures of all groups during performance of knee extensions at 100–50% of single maximal resistance (1 RM). Values are means ± SE. Filled circles and open circles, control; filled squares and open squares, novice group; filled triangles and open triangles, body builders. a, across groups peak pressures significantly greater than body builders \((P < 0.05)\); b, across % of 1 RM peak systolic and diastolic pressures are significantly greater than 1 RM \((P < 0.05)\); c, across % of 1 RM peak systolic pressure significantly greater than 1 RM \((P < 0.05)\).

FIG. 2. Peak systolic and diastolic blood pressures of all groups during performance of arm presses at 100–50% of single maximal resistance (1 RM). Values are means ± SE. For definitions of symbols see Fig. 1.

FIG. 3. Heart rate of all groups during performance of knee extensions at 100–50% of single maximal resistance (1 RM). Values are means ± SE. Circles, control group; squares, novice group; triangles, body builders. a, across groups peak heart rate significantly greater than body builders \((P < 0.05)\); b, across % of 1 RM peak heart rate significantly greater than 1 RM \((P < 0.05)\).

FIG. 4. Heart rate of all groups during performance of arm press at 100–50% of single maximal resistance (1 RM). Values are means ± SE. For definitions of symbols see Fig. 3.

Across groups, the magnitude of the control group's heart rate response during arm presses was significantly greater \((P < 0.05)\) than the novice and body building groups. During knee extensions, no significant difference \((P < 0.05)\) in magnitude of heart rate response between the three groups was demonstrated. During both exercises across treatments, the magnitude of the heart rate response was significantly greater \((P < 0.05)\) at 90, 80, 70, and 50% of 1 RM than at 1 RM. The greatest peak heart rate \((135 ± 6 \text{ beats/min})\) and magnitude of response \((69 ± 6 \text{ beats/min})\) in heart rate was shown by the control group during arm presses at 70% of 1 RM.

DISCUSSION

The major finding of this study is previous resistance-training experience can decrease the blood pressure
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1 and 2) and heart rate response (Figs. 3 and 4) to common upper and lower body resistance-training exercises. In addition, generally, greater pressor responses are demonstrated during sets carried to voluntary fatigue at various percent of 1 RM than at 1 RM. Both these findings are apparent whether the blood pressure and heart rate responses to resistance-training exercises are expressed in terms of peak values or in magnitude of response (i.e., peak value minus resting value).

The control and activation mechanisms of the pressor response are not fully understood and reviewed elsewhere (6, 12, 16, 22). Several explanations of the lowered pressor response in body builders are plausible. Although recently disputed (5, 9), it has been demonstrated that a lower pressor response is demonstrated by muscles composed predominately of slow-twitch fibers (3, 16, 19).

The possibility does exist that the body builders had a greater predominance of slow-twitch fibers than the other two groups. We did not determine fiber-type composition of the subjects in the present study. Previous studies indicate, however, that the percent of slow-twitch fibers in the arm (13, 14, 24) and quadriceps (4, 24, 25) muscles of body builders are not significantly different than that of control subjects. This explanation, therefore, is in question. Other possible explanations are that resistance training may desensitize the sympathetic nervous system (7) and/or lead to a resetting of the threshold of the peripheral baroreceptors (23). Either of these explanations could result in a lowered pressor response in the body builders.

The body builders demonstrated lower peak heart rates than the other two groups during both exercises (Figs. 3 and 4). Magnitude of heart rate response of the body builders was lower than the control group only during arm presses. This difference in heart rate response between the arm press and knee extension exercises is probably due to the greater use of the lower limbs in everyday activity as compared with the upper limbs. The lowered heart rate response when present probably involves an increase in parasympathetic stimulation and/or a decrease in sympathetic stimulation to the myocardial tissue during performance of exercise (1, 19).

The body builders utilized greater resistances than the control and novice groups during the performance of both exercises. The control, novice, and body builder groups utilized 0.14, 0.18, and 0.22 kg resistance/kg body wt and 0.16, 0.18, and 0.20 kg resistance/kg body wt in the arm press and knee extension exercises, respectively. Thus adaptations in the pressor response, where apparent, reduce the pressor response not only at the same relative resistance but also at greater absolute resistances.

No significant difference in the blood pressure response between the arm press and knee extension exercises was demonstrated. Previous studies have shown a direct relationship between muscle mass involved in dynamic weight-training exercises and the blood pressure response (10, 15). The present study appears to contradict these previous results. We did not directly determine the active muscle mass involved in the exercises performed. However, a one-arm overhead press involves the forearm, shoulder, triceps, and muscles that stabilize the scapulae; and a one-leg knee extension involves the quadriceps group. The inclusion of these accessory muscles in the arm press makes the total muscle mass involved similar to that utilized in a one-leg knee extension exercise.

The higher peak and magnitude of response in blood pressures and heart rates during knee extensions demonstrated during sets to voluntary fatigue at various percent of 1 RM than at 1 RM are in agreement with previous studies (8, 15). This same pattern is apparent for the arm press except the pressure responses are not significantly different. Peak heart rates in the present study normally occurred during the last two to three repetitions of a set, which is in agreement with a previous study (15).

Few studies have examined the cardiovascular responses (8, 10, 15, 18) during performance of weight training and differences in protocol, equipment, and the use of different exercises make comparisons between studies difficult. However, results of the control and novice groups in the present study for peak and magnitude of response of systolic pressure are of the same magnitude and peak diastolic pressures higher than those reported for untrained men performing two-leg leg extension (10). Intra-arterial blood pressures during dynamic weight training that are substantially higher than the present studies have also been reported (15). The exercises utilized in this previous study (15) normally involved a larger muscle mass (variations of the leg press exercise), and this would result in a greater pressor response (10).

Although the present study took precautions to minimize the performance of a Valsalva maneuver, the blood pressure tracings immediately after cessation of exercise did show indications of performance of a Valsalva maneuver in 16% of the sets performed. However, we know of no published data comparing the pressor response during dynamic muscular contractions with and without a Valsalva maneuver. Therefore, the effect on the blood pressure response during dynamic muscular contractions with and without a Valsalva maneuver is unclear.

Peak heart rates and magnitude of heart rate responses demonstrated by the control and novice groups are of the same magnitude reported for untrained males performing a double knee extension (10) and weight trained males performing the bench press (8). The heart rate response of all three groups is less than that reported for weight-trained subjects performing back lifts and squatting-type exercises (8, 15). This difference may be due to differences in the muscle mass involved in the dynamic contraction as has been reported previously (8). Two of these previous studies (8, 15) allowed the performance of a Valsalva maneuver. If heart rate were determined during phase 2 or 4 of the Valsalva maneuver, heart rate would be elevated. This elevated heart rate would reflect the performance of the Valsalva maneuver and not the exercise performed per se.

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REFERENCES


