INFLUENCE OF REST INTERVAL LENGTHS ON HYPOTENSIVE RESPONSE AFTER STRENGTH TRAINING SESSIONS PERFORMED BY OLDER MEN

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1Federal University of Rio de Janeiro, Physical Education Post-Graduation Program, Rio de Janeiro, Brazil; 2Department of Exercise Physiology, Plínio Leite University, Niterói, Brazil; 3Department of Physical Education, Londrina State University, Paraná, Brazil; and 4Department of Interdisciplinary Health Sciences, AT Still University, Mesa, Arizona

ABSTRACT

de Salles, BF, Maior, AS, Polito, M, Novaes, J, Alexander, J, Rhea, M, and Simão, R. Influence of rest interval lengths on hypotensive response after strength training sessions performed by older men. J Strength Cond Res 24(11): 3049–3054, 2010—The purpose of this study was to compare the postexercise hypotensive response after different rest intervals between sets (1 and 2 minutes) in normotensive older men. Seventeen older men (67.6 ± 2.2 years) with at least 1 year of strength training experience participated. After determination of 10 repetition maximum (10RM) loads for exercises, subjects performed 2 different strength training sessions. On the first day, volunteers performed 3 sets of 10 repetitions per exercise at 70% 10RM, with 1 or 2 minutes’ rest interval between sets depending on random assignment. On the second day, the procedures were similar but with the other rest interval. There was no difference in systolic and diastolic blood pressure between rest intervals at any time point measure. Before 1- and 2-minute sessions, the systolic blood pressure values were 122.7 ± 6.0 and 123.2 ± 3.7 mm Hg, and diastolic blood pressure values were 80.5 ± 5.6 and 82.0 ± 3.7 mm Hg, respectively. Both 1 and 2 minute sessions still presented reduced values for systolic blood pressure after 60 minutes (102.9 ± 6.9 and 106.7 ± 5.4 mm Hg, respectively), while the diastolic blood pressure presented significant reductions for 50 minutes after a 1 minute session (12.1 to 5.6 mm Hg) and for 60 minutes after the 2 minute session (13.3 to 6.5 mm Hg). Additionally, the systolic and diastolic blood pressure effect size data demonstrated higher magnitudes at all time point measures after the 2-minute rest sessions. These results suggest a poststrength training hypotensive response for both training sessions in normotensive older men, with higher magnitudes for the 2-minute rest session. Our findings suggest a potentially positive health benefit of strength training.

KEY WORDS blood pressure, hypotension, resistance training, weight training, older adults

INTRODUCTION

Strength training is prescribed for the control of resting blood pressure in hypertensive and normotensive individuals (1). Meta-analytical data suggest that strength training of varying prescriptions can decrease mean resting blood pressure by as much as 3–4 mm Hg (4). However, blood pressure also drops acutely after strength training as a postexercise hypotensive response. In this case, the reductions found in the literature are vary considerably because of differences in prescription variables, health status of the sample, and training volume (6,13,21). The acute training program variables such as exercise order, rest periods between sets, specific exercises and session format, weekly frequency, movement velocity, training duration and volume, number of repetitions, sets, and load or intensity can all be manipulated to meet the training goals and individual differences in training needs between individuals (2,10,17,19,20). However, few studies have compared the effect of different training program variables on the postexercise hypotensive response in older adults. Simão et al. (21) observed the blood pressure response after different training intensities (repetition maximum [6RM] and 12 repetitions using 50% of 6RM), volumes (6 and 12 repetitions), and sessions formats (set repetition format and circuit training). The results suggested that strength training intensity can affect the duration but not the magnitude of the postexercise hypotensive response.

Although strength training intensity may affect the duration of the hypotensive response, the manipulation of different training program variables on the hypotensive effect is unknown. The identification of specific effects on blood
pressure responses after the alteration of different training variables is important to ensure the optimal, and appropriate, prescription of strength training for individuals concerned about blood pressure responses such as those with chronic hypertension. Because of the relatively little information available on the existence of a postexercise hypotensive response after strength training, this study was undertaken. The purpose of this study was to compare the postexercise hypotensive response after strength training sessions performed with different rest intervals between sets (1 and 2 minutes) in normotense older men.

METHODS

Experimental Approach to the Problem

To investigate the effect of strength training with different rest intervals on the postexercise hypotensive response, subjects performed 2 strength training sessions. After the determination of 10RM loads for each exercise of the sequence in a test and retest, the subjects were randomly assigned to a 1- or 2-minute rest interval session in the first day, and on the other day, the procedures were exactly the same but with the other rest interval. Blood pressure was measured before and at 10-minute intervals for 60 minutes after strength training sessions.

Subjects

Seventeen normotense older men (Table 1) with at least 1 year of strength training experience participated in the present study. All subjects answered the Physical Activity Readiness Questionnaire (18) and signed an informed consent form before participation. According to the Declaration of Helsinki, the following exclusion criteria were adopted:

<table>
<thead>
<tr>
<th>Subject Characteristics</th>
<th>Mean ± SD</th>
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<tbody>
<tr>
<td>Age (y)</td>
<td>67.6 ± 2.2</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>172 ± 6.6</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>76.29 ± 8.3</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.5 ± 2.3</td>
</tr>
<tr>
<td>SBP (mm Hg)</td>
<td>122.9 ± 4.9</td>
</tr>
<tr>
<td>DBP (mm Hg)</td>
<td>81.2 ± 4.7</td>
</tr>
</tbody>
</table>

*BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure.
†Values are given as mean ± SD.

Figure 1. Systolic blood pressure response to the 2 resistance exercise sessions (mean ± SD). *Significant difference from rest in the 1-minute rest interval session at that time point. #Significant difference from rest in the 2-minute rest interval session at that time point.
(a) use of medication affecting their cardiovascular responses and (b) existence of osteoarticular and cardiovascular problems that might influence the performance of the proposed exercises. All the subjects did not ingest caffeine or alcohol during the 24-hour period before any of the testing protocols and did not perform any vigorous physical activity during the 48 hours before any testing protocols.

Ten Repetition Maximum Testing

Previous to 10RM testing and strength training session protocols, the subjects participated in a cardiologic evaluation, including a resting 12-lead electrocardiogram. After the resting electrocardiogram was evaluated and before performing the tests to obtain 10RM, all subjects performed 3 sessions to become familiar with the proposed exercises in the 10RM test, at intervals from 48 to 72 hours. To obtain reliable 10RM loads, data were assessed during 2 nonconsecutive days following the exercise sequence: leg press 45° (LP), bench press (BP), leg extension (LE), lat pull down wide grip (LPD), leg curl (LC), seated military press (MP), and seated calf raise (SC). During the 10RM test, each subject performed a maximum of 3 10RM attempts for each exercise with 5-minute rest intervals between attempts (21). After the 10RM load in a specific exercise was determined, an interval not shorter than 10 minutes was allowed before the 10RM determination of the next exercise. Standard exercise techniques were followed for each exercise. A paired student t-test did not show significant differences between the 10RM tests for any of the exercises. The heaviest load achieved in both days was considered the 10RM.

Strength Training Sessions

The 2 strength training sessions were performed on non-consecutive days with at least 72 hours between experimental sessions. On the first day, all subjects performed 3 sets of 10 repetitions in each exercise with 70% of 10RM, and 1- or 2-minute rest interval between sets and exercises depending on random assignment. On the second day, the procedures were exactly the same but with the other rest interval. No pause was allowed between the eccentric and concentric phase of a repetition or between repetitions, and the exercise sequence was exactly the same for 10RM testing. During all strength training sessions, subjects were asked not to perform a Valsalva maneuver. Strength training sessions of individual subjects were performed at the same approximate time of the day.

Before the beginning of each strength training session, the subjects rested quietly in a seated position for 10 minutes after which resting blood pressure was measured. After each strength training session, blood pressure was measured at 10-minute intervals for 60 minutes, resulting in a total of

![Graph showing diastolic blood pressure response to the 2 resistance exercise sessions (mean ± SD). *Significant difference from rest in the 1-minute rest interval session at that time point. #Significant difference from rest in the 2-minute rest interval session at that time point.](image-url)
Rest Intervals and Hypotensive Response Poststrength Training

6 readings after each strength training session. Before and after each session, subjects were fitted with ambulatory blood pressure monitoring equipment (Spacelabs Medical, Redmond, WA, USA), and this equipment was used for all pre and postsession blood pressure measurements. The ambulatory blood pressure equipment was autocalibrated before each use to ensure accuracy. During blood pressure pre and postsession monitoring, subjects remained in a seated position in a temperature-controlled quiet room (23°C).

**Statistical Analyses**

All data are presented as mean ± SD. The statistical analysis was initially performed using the Shapiro–Wilk normality test and the homocedasticity test (Bartlett criterion). All variables presented normal distribution and homocedasticity, so a 2-way repeated-measures analysis of variance (1 minute vs. 2 minutes) followed by Tukey’s post hoc test was used for the analysis of possible differences in postexercise systolic and diastolic blood pressure. The level of significance was set at $p \leq 0.05$ for all statistical procedures. Additionally, to determine the magnitude of the findings, effect sizes (ESs; the difference between pretest and posttest scores divided by the pretest SD) were calculated for the systolic and diastolic blood pressure responses for both rest intervals, and the scale proposed by Rhea (16) was used to determine the magnitude of the ES. The software Statistica 6.0 (Stasoft, Tulsa, OK, USA) was used for all statistical analyses.

**RESULTS**

The 10RM intraclass coefficients for each exercise were as follows: LP = 0.92, BP = 0.96, LE = 0.98, LPD = 0.98, LC = 0.96, MP = 0.94, and SC = 0.96. Figure 1 shows the systolic blood pressure values after strength session with 1- and 2-minute rest interval. There was no significant difference in systolic blood pressure between rest interval durations after strength training sessions. However, there was significant difference in systolic blood pressure after strength training sessions compared with values at rest or before strength training sessions with both rest interval durations (1 and 2 minutes).

Figure 2 shows the diastolic blood pressure values after strength sessions with 1- and 2-minute rest interval. There was no significant difference in diastolic blood pressure between rest interval durations after strength training sessions. However, there was a significant difference in diastolic blood pressure poststrength training sessions compared with values for 50 minutes after the 1 minute rest interval session and for 60 minutes after the 2 minute rest interval session.

Table 2 shows the systolic and diastolic blood pressure ES after strength sessions with 1- and 2-minute rest interval. Systolic and diastolic blood pressure ES of both rest interval conditions presented large values, with the exception of diastolic blood pressure at 40, 50, and 60 minutes after the 1 minute rest interval session that presented moderate values. Additionally, higher systolic and diastolic blood pressure ES were observed for the 2-minute rest interval condition at all time point measures.

**DISCUSSION**

The major finding of the present study was that both training programs resulted in a significant hypotensive effect that remained after 60 minutes. Furthermore, the ES data demonstrated higher magnitudes at all time point measures after the 2-minute rest sessions, suggesting that a 2-minute rest interval may be more efficient to produce a greater hypotensive response. This conclusion is supported by both the systolic and diastolic blood pressure hypotensive response. This result suggests that the duration of the hypotensive response may not be so related to rest interval between sets and exercises, whereas the magnitude of the

| Table 2. Systolic, diastolic, and mean blood pressure effect sizes responses to the 2 resistance exercise sessions.* |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                 | 10 min          | 20 min          | 30 min          | 40 min          | 50 min          | 60 min          |
| **SBP**         |                 |                 |                 |                 |                 |                 |
| 1-min rest interval | 3.66            | 3.36            | 3.33            | 3.46            | 3.25            | 3.30            |
|                 | Large           | Large           | Large           | Large           | Large           | Large           |
| 2-min rest interval | 7.86            | 6.83            | 6.21            | 5.62            | 5.13            | 4.45            |
|                 | Large           | Large           | Large           | Large           | Large           | Large           |
| **DBP**         |                 |                 |                 |                 |                 |                 |
| 1-min rest interval | 2.16            | 1.94            | 1.67            | 1.23            | 1.00            | 0.60            |
|                 | Large           | Large           | Large           | Large           | Moderate        | Moderate        |
| 2-min rest interval | 3.59            | 3.02            | 2.86            | 2.70            | 2.27            | 1.75            |
|                 | Large           | Large           | Large           | Large           | Large           | Large           |

*SBP = systolic blood pressure; DBP = diastolic blood pressure.
hypotensive effect seems to be influenced by the rest-interval length between sets.

To the authors’ knowledge, this is the first work presenting the postexercise blood pressure response at different passive rest interval lengths between sets and exercises. The rest interval is associated with the intensity of the strength training and different rest-interval lengths with the same load can provide different degrees of effort (10). In the present study, it is possible that the session with 1-minute rest intervals generated greater discomfort and represented a more “intense” training than the session with 2-minute rest intervals. However, the ES data demonstrated a higher hypotensive magnitude response for the 2-minute session, what was surprising. For aerobic exercises, greater reductions in systolic blood pressure were observed with 61–90 minutes vs. 30–60 min wk⁻¹ (1). Similarly, because the 2-minute session presented a longer duration, and consequently longer time of exposition to strength training stimulus, we speculated that the session’s duration may be more important than the training intensity to achieve higher magnitudes of the post–strength training hypotensive response.

A number of investigations have examined the hypotensive response to different strength training intensities. Previous studies comparing only different training intensities have shown no significant difference between the magnitude and the duration of the postexercise hypotensive response with intensities ranging from 40 to 80% of 1RM (3,5,7). A relatively recent study showed that after strength exercises with intensities of 80 and 40% of 1RM, the systolic blood pressure remained reduced for 90 minutes after, in association with a reduction of cardiac output (15). On the other hand, the diastolic blood pressure was reduced for a shorter period only after the intensity of 40% of 1RM but through the same behavior of reduced cardiac output. To compensate for this fall in cardiac output, the heart rate remained elevated. In this way, substantial postexercise blood flow from the heart occurs and should occur as well with parasympathetic prevalence in peripheral areas (10). Therefore, as was noted by Rezk et al. (15), the reduction mechanisms of blood pressure post–strength training seem to be the same, independent of the load or intensity.

Contrary to the results of previous studies (3,5,7,14), and in accordance with the results by Rezk et al. (15), Simão et al. (21) observed a similar blood pressure magnitude, but with different durations of hypotensive responses when comparing strength training in a circuit session vs. a traditional session format with the same total volume and different intensities. In this study, the circuit session was accomplished with lower intensity (50% of 6RM load), and the traditional session format was accomplished with a higher intensity (6RM load). Consequently, the higher intensity session resulted in a more prolonged hypotensive effect. Dissimilar to our results for different rest interval lengths between sets, the Simão et al. (21) results suggest that strength training intensity can affect the duration but not the magnitude of the postexercise hypotensive response.

The possible reason for this contradiction between the results found by Simão et al. (21) with previous studies is unclear. Simão et al. (21) used sets to failure but in previous studies (3,5,7) comparing different intensities whether or not sets to failure was used is at times unclear; however, it appears that sets were not performed using true RM loads. Additionally Simão et al. (21) used circuit sessions. There are a few studies that used circuit strength training to analyze postexercise blood pressure response, and none of them intended to investigate possible mechanisms related to the hypotensive response. Hill et al. (8) verified reduction in diastolic blood pressure during 60 minutes after 3 sets of 4 exercises performed to exhaustion with 70% of 1RM in circuit. Furthermore, Fisher (6) also observed reduction in the systolic blood pressure for 60 minutes, after 3 sets of 5 exercises (15 repetitions) with 50% of 1RM. A circuit strength training session, with reduced rest interval lengths between the exercises, may have a similar impact on postexercise blood pressure as aerobic exercise in some way. However, strength training sessions are usually accomplished with different muscle groups not allowing for maintenance of hemodynamic responses during training.

The results of the present study demonstrating reductions in postexercise systolic and diastolic blood pressure may be because of the older age of the subjects. No studies exist in the literature that have examined the postexercise hypotensive response in older men. In fact, few studies examining the hypotensive effects of strength training are available, and in most of these studies, the sample was composed of subjects under the age of 50 years. Therefore, comparison of postexercise hypotension between an older sample and younger people is warranted. For instance, several studies with young people demonstrated reduction in the systolic (6,11,14) or diastolic blood pressure (5,8). However, only 2 studies demonstrate simultaneous reduction in both systolic and diastolic blood pressure (15,21), yet with only a short duration in the reduction of diastolic blood pressure. Therefore, the age group in the present study is a plausible explanation for the present data demonstrating reductions in the systolic and diastolic blood pressure for 60 minutes. It is common among older individuals to have an increase of sympathetic activity at rest, which can be suppressed after exercise (12). On the other hand, asymptomatic young adults should not possess autonomous modifications at rest (9). Consequently, the behavior of the blood pressure after exercise in young adults can be well differentiated between that observed in older men. Furthermore, although the present study demonstrated a greater hypotensive effect of strength training on blood pressure in normotensive older subjects than the younger subjects of previous studies, the results also indicated that the strength training hypotensive effect in older hypertensive subjects may be more elevated. However, future studies are necessary to verify if this is true.
Rest Intervals and Hypotensive Response Poststrength Training

The present study demonstrated a reduction in the systolic and diastolic blood pressure after strength training in older men, and both strength training programs resulted in a significant and prolonged hypotensive response. However, unexpected higher magnitudes were observed for 2-minute rest interval length. These findings suggest that there is a poststrength training hypotensive effect in older men and longer rest between sets may be more efficient to promote higher blood pressure reductions. However, the effects of different training prescriptions are still unknown and further research should be conducted examining the influence of different training variables on the postexercise response. Specifically, research is warranted that examines the hypotensive response post-strength training with > 2-minute rest intervals between sets. Such research will enable exercise professionals to more effectively prescribe strength training for older men.

**Practical Applications**

Strength training programs, including 1- and 2-minute rest intervals between sets, such as used in the present study may be efficient at controlling blood pressure in older men. However, strength training programs that involve 2-minute rest intervals between sets may be even more effective at controlling blood pressure in this population. Therefore, if older adult clients are not bound by time constraints and blood pressure control is a training goal, the use of 2-minute rest intervals is recommended. Indeed, the results are relevant to health and fitness professionals of older adults providing important information and examples of strength training program designs that result in a prolonged, substantial hypotensive effect.

**References**