Hypotensive Effect of Resistance Training Performed on Stable vs. Unstable Surfaces

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ABSTRACT

Senna G, Oliveira CQ, Kreuger S, Scudese E, Monteiro W. Hypotensive Effect of Resistance Training Performed on Stable vs. Unstable Surfaces. JEPonline 2016;19(1):17-26. The purpose of this study was to compare the systolic blood pressure (SBP) and diastolic blood pressure (DBP) responses during two different strength training (ST) surfaces: stable (SST) and unstable (UST). Fifteen trained normotensive women performed 4 nonconsecutive 10RM load test sessions (test and retest for both surface methods) for a whole-body workout. After the load tests, subjects performed two training sessions (SST and UST) with 3 sets of each exercise with loads of 85% of 10RM with a 2-min rest between sets and exercises. The ANOVA two-way showed the same pattern of magnitude reduction on SBP after both training sessions (SST and UST). However, a prolonged reduction of SBP was evident from the SST method (~60 min). For DBP, there were no significant differences between workouts. Thus, although a ST session might trigger a general post-exercise hypotensive effect regardless of the surface method applied (SST and UST), it seems that this effect is more durable after sessions performed with the traditional SST.

Key Words: Strength training, Blood pressure, Post-exercise hypotension, Core training
INTRODUCTION

The systemic arterial hypertension is acknowledged to be an independent risk factor for stroke, coronary artery disease, and kidney failure (17). Physical exercise has been recommended as an effective non-pharmacological strategy for preventing and controlling hypertension (1, 22). In this context, it has been proposed that strength training (ST) can also promote chronic reduction in blood pressure.

Previous studies suggest that chronic reduction in blood pressure can be related to acute decrease after exercise (11). Therefore, it seems feasible that the potential chronic effects of ST on blood pressure may also be a function of the training sessions to induce acute reduction in blood pressure, which is usually referred to as a post-exercise hypotension (PEH) phenomenon. Accordingly, it has been shown that ST sessions can elicit decreases in both systolic (SBP) and diastolic blood pressure (DBP) of 3.0 to 3.5 mmHg for approximately 60 min post-exercise (7,8).

The hypotensive response to acute ST seems to be affected by different combinations of training variables (8,9,20). For instance, it has been shown that exercise intensity influences duration, but not the magnitude of PEH (20,21). Additionally, some previous research suggests that the amount of exercised muscle mass may also be a determinant of PEH after acute ST (15). When considering these findings, it is important to investigate how different strategies involving the combination of methodological variables of ST (such as volume, intensity, muscle mass, and type of exercise) may affect the PEH response.

Recently, the implementation of unstable surface training (UST) within ST has previously claimed to increase neuromuscular activity by means of stimulating the stability control (23). The major premise of eliciting strength gains using an UST strategy might be related to an improvement of balance and muscular activation of specific areas of the body (3,4,10,23). Briefly, the UST increases the recruitment of motor units; consequently, UST increases muscle activity during the training session. Since the amount of exercised muscle mass seems to be related to PEH due to acute ST (15), it would be of practical interest to investigate whether ST performed traditionally (e.g., stable surface training, SST) compared to UST will induce similar or even a distinct PEH response. However, we did not found any previous research addressing this matter.

Thus, the purpose of this study was to compare the acute blood pressure responses following strength exercises performed on the SST versus the UST surfaces. We hypothesized that the UST sessions will promote a greater hypotensive response compared to the SST sessions.

METHODS

Subjects
Fifteen physically active women (21.7 ± 5.0 yrs; 61.4 ± 7.2 kg, 161 ± 5 cm) with normal blood pressure participated in this study. All subjects were evaluated within the luteal phase of their menstrual cycle. Subjects were excluded if they: (a) exhibited musculoskeletal impairments that might interfere with strength training (ST) or cardiovascular diseases (e.g., hypertension, coronary disease, etc.); and (b) use ergogenic drugs or medication affecting cardiovascular responses at rest or during ST. All subjects responded negatively to the PAR-Q (19). The
study was approved by the institutional ethical committee and written informed consent was obtained from all subjects in accordance with the Helsinki Declaration.

**Ten Repetition Maximum Test (10RM)**

Initially, clinical examination, anthropometric, and resting blood pressure assessments were performed. The following exercises were tested and retested for 10RM on a traditional stable surface: barbell squat (SQ), barbell bench press (BP), unilateral squat (US), dumbbell shoulder press (SP), and stiff legged deadlift (SLD). All subjects were instructed to perform repetitions to concentric failure. During the 10RM tests, each subject performed a maximum of three 10RM attempts for each exercise with 10 min of rest. Each testing session was separated by 48 hrs, during which the subjects were restricted from performing any type of exercise. During the second day of the tests, all procedures were repeated, but with an inverted exercise order.

To minimize errors, the following strategies were used: (a) standard instructions concerning the testing procedures were given to the subjects before the test; (b) subjects received standardized instructions on exercise technique; and (c) verbal encouragement was provided during the testing procedure. On the 3rd day of the tests, subjects performed all exercises using an unstable surfaces training protocol (UST). The exercise order was repeated from the 1st day of the tests with the inclusion of unstable implements like the Swiss ball and the Bosu®. The methodological procedures used to determine loads of 10RM on UST were the same as adopted on the 1st day of workload tests. Then, at the 4th day, all procedures were repeated, but with an inverted exercise order. All testing sessions were performed at the same time of the day for all subjects.

**Blood Pressure Assessment**

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were assessed before and after exercises performed on SST and UST conditions. Before each exercise session, all subjects were instructed to remain resting in a seated position for at least 10 min in a low light and quiet environment. Then, blood pressure was assessed using an oscillometric device (Omron MX3 Plus; Omron Healthcare Europe B.V. Hoofddorp, Netherlands) as validated elsewhere (6). After the exercise sessions, SBP and DBP were assessed within the 1st min (immediately post-exercise) and each 10 min during the 60-min post-exercise recovery period in the same conditions described for the resting assessment.

**Experimental Approach**

Forty-eight hours after the loading tests, the subjects performed two different experiential training sessions (SST and UST) with an alternate order for each subject. The exercise order for each protocol remained the following: BS, BP, US, SP, and SLD with 3 sets of each exercise and loads of 85% of 10RM followed by a 2-min rest interval between sets and exercises. Systolic blood pressure and DBP were assessed before, after, and at each 10 min during the 60-min post-exercise recovery in different surface conditions (SST and UST).

The implementation of Bosu® and Swiss ball were exclusive for the UST protocol. Verbal encouragement was performed by an experienced professional, following previously described procedures (13). The warm-up before each session consisted of two sets of 12 repetitions with 40% of 10RM load running on the initial exercise of the training session. No attempt was made to control the speed of repetition, but the subjects were instructed to
perform a cadenced and control the movement. All sessions were conducted at the same time of day for each subject. The subjects were instructed not to perform any type of physical activities and not to ingest beverages containing alcohol or caffeine in the 48 hrs prior to the experimental sessions.

**Statistical Analysis**

All results are presented as mean ± standard deviation (SD). The intraclass correlation coefficient was calculated to assess the 10RM load reproducibility in the SST and the UST conditions. A 2-way ANOVA with repeated measures was applied to test potential differences in SBP and DBP during recovery from the different training protocols (SST and UST), followed by Bonferroni post hoc verification.

Additionally, to determine the magnitude of the results, the effect size (the difference between pre blood pressure, i.e., the pre-test and blood pressure of each verification moments, divided by the standard deviation of pre-test) was calculated for each set compared to the initial blood pressure. For SBP and DBP data, the area under the curve was calculated using the trapezoidal method and compared between SST and UST using a paired means t-test. The limits proposed by Cohen (5) were applied to determine the magnitude of treatment effect. In all cases, significance level was set at P≤0.05, and calculations were made using the Statistica 7.0 software (Statsoft™, Tulsa, OK, USA).

**RESULTS**

The intraclass correlation coefficient showed high reliability between loads between test-retest for all exercises in SST (SQ, r = 0.97; BP, r = 0.92; US, r = 0.94; SP, r = 0.92; ST, r = 0.95; P<0.0001) and UST (SQ r = 0.91; BP r = 0.98; US, r = 0.92; SP, r = 0.96; ST, r = 0.94; P<0.0001). There was no significant difference between protocols. However, a significant decline in SBP was evident for both protocols as soon as 10 min had elapsed after the post-verification. This decline was sustained for 60-min post-intervention for the SST, but lasted only until the 40-min window for the UST protocol.

In addition, the area under the curve for SBP did not differ (P = 0.56) between the SST (6392.66 ± 396.64 mmHg⁻¹·min⁻¹) and UST (6330.33 ± 363.57 mmHg⁻¹·min⁻¹) conditions. As for the DBP, no significant differences compared to pre-test were observed in either protocol. However, there was a significant reduction on DBP on both 20th and the 30-min post-intervention assessments, compared to the immediately post-verification (Figure 2). In addition, the area under the curve for DBP did not differ (P = 0.79) between the SS (4083.33 ± 368.19 mmHg⁻¹·min⁻¹) and UST (4063.01 ± 425.99 mmHg⁻¹·min⁻¹) conditions.

A large magnitude effect size was observed in both training protocols (SST and UST) for SBP during post-verifications. The SST presented large magnitude effect on all post-verifications until a 60-min time window. The UST presented a large magnitude hypotension effect only at the 40-min post verification. For DBP, SST and UST presented moderate to trivial changes (respectively) during the post-exercise period. These changes started at a 10-min post-exercise for the SST protocol and were sustained to the last 60-min verification. For the UST, except for the moderate effect observed at 20-min post-exercise, all other verifications presented a trivial variation.
Figure 1. SBP (a) and DBP (b) response on stable and unstable surface protocols.
*Significant difference (P<0.05) compared to pre-exercise; #Significant difference (P<0.05) compared to pre-post-exercise.

Table 1: Size Effect Values of SBP and DBP on Both Protocols.

<table>
<thead>
<tr>
<th></th>
<th>SST</th>
<th>UST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Systolic Blood Pressure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post</td>
<td>0.99 (large)</td>
<td>1.02 (large)</td>
</tr>
<tr>
<td>10 min</td>
<td>1.11 (large)</td>
<td>0.93 (large)</td>
</tr>
<tr>
<td>20 min</td>
<td>1.08 (large)</td>
<td>0.84 (large)</td>
</tr>
<tr>
<td>30 min</td>
<td>1.19 (large)</td>
<td>0.92 (large)</td>
</tr>
<tr>
<td>40 min</td>
<td>1.23 (large)</td>
<td>1.06 (large)</td>
</tr>
<tr>
<td>50 min</td>
<td>1.02 (large)</td>
<td>0.51 (moderate)</td>
</tr>
<tr>
<td>60 min</td>
<td>1.03 (large)</td>
<td>0.61 (moderate)</td>
</tr>
<tr>
<td><strong>Diastolic Blood Pressure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post</td>
<td>0.10 (trivial)</td>
<td>0.79 (moderate)</td>
</tr>
<tr>
<td>10 min</td>
<td>0.72 (moderate)</td>
<td>0.03 (trivial)</td>
</tr>
<tr>
<td>20 min</td>
<td>0.52 (moderate)</td>
<td>0.41 (moderate)</td>
</tr>
<tr>
<td>30 min</td>
<td>0.60 (moderate)</td>
<td>0.27 (trivial)</td>
</tr>
<tr>
<td>40 min</td>
<td>0.62 (moderate)</td>
<td>0.14 (trivial)</td>
</tr>
<tr>
<td>50 min</td>
<td>0.55 (moderate)</td>
<td>0.16 (trivial)</td>
</tr>
<tr>
<td>60 min</td>
<td>0.41 (moderate)</td>
<td>0.03 (trivial)</td>
</tr>
</tbody>
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SST = Stable Surface Training; UST = Unstable Surface Training
DISCUSSION

The main finding of this study is the overall decrease in blood pressure (SBP and DBP) resulting from the two different ST protocols on normotensive women. Although no major difference was found in both SBP and DBP at distinct training protocols (SST and UST), the SST decreased SBP over a longer period of time compared to the UST. Thus, it appears that a possible increase in muscle activation (due to increased load) may have been the reason why the UST did not reflect a greater hypotensive response of either magnitude or duration in SBP. Whatever the reason might be, the findings support the established consensus for using SST to lower blood pressure values even in normotensive populations (1,22). Thus, this study contributes to the overall understanding that the SST is the preferable choice when preventing hypertension.

To the authors' knowledge, this is the first study that compares post-exercise hypotension responses in SST and UST protocols. Several other studies have analyzed the post-exercise hypotensive effect induced by traditional strength training (ST) performed on a stable surface. Specifically, de Salles et al. (9) compared the post-exercise hypotension response with different rest intervals between sets (1 and 2 min) in 17 normotensive elderly subjects who were experienced in ST. The subjects underwent two different training sessions. At first, they performed 3 sets of 10 repetitions per exercise with loads of 70% of 10RM with a 1 or 2-min rest interval between sets depending on random assignment. In the second session, the other rest interval was applied. According to the authors, significant differences in post-exercise were evident between the rest intervals in SBP and DBP on all verification moments. Furthermore, the effect size of the SBP and DBP demonstrated increased magnitude at all post-exercise moments for the 2-min rest protocol. These results suggest higher magnitudes for the hypotensive response resulting from the 2-min rest interval. These findings support the concept that distinct training protocols might promote different effects on post-exercise hypotension. In part, our experiment contributes to this concept once the SST protocol differed from UST resulting on greater duration, not magnitude, for the hypotensive response.

Other experiments have previously investigated the effect of ST on SBP and DBP in young men (2,20,21). Simão et al. (20) investigated two different ST intensities, volume and method on the hypotensive effect. Briefly, they investigated the differences in SBP and DBP at post-exercise on 5 and 6 exercise (volume) loads of six 6RM and 12 repetitions with 50% of 6RM (intensity) repeated and paired sets (training method). The results of the study indicate that the ST intensity influenced the duration, but not the magnitude of the post-exercise hypotension response. Also, Arazi and Afkhami (2) compared SBP and DBP responses after two circuit protocols with different rest intervals. For this purpose, 11 normotensive men underwent two circuit training sessions with rest intervals of 30 and 40 sec between exercises and an additional control session (untrained). The results demonstrated a reduction of SBP values in both protocols on post-exercise moments. However, for DBP no differences occurred on post-exercise in relation to rest. The authors did not find any difference between training protocols for both SBP and DBP.

Simões et al. (21) analyzed SBP and DBP post-exercise responses in middle-aged type 2 diabetics and non-diabetics individuals. The subjects underwent three sessions: (a) one for control; (b) one session for 3 sets of a ST circuit containing 6 exercises with 16 repetitions each at 43% of 1RM, higher intensity; and (c) another equally designed session with 30
repetitions of 23% of 1RM, lower intensity. The authors reported a significant decrease in post-exercise SBP in the higher intensity protocol. There were no significant changes observed with the lower intensity protocol.

The studies of Arazi and Afkhami (2), Simão et al. (20), and Simões et al. (21) are in agreement with the present study by the fact that a higher training intensity presents a strong correlation with a positive acute post-exercise hypotension. However, it is important to remember that our experiment differed methodologically from the other investigations. The findings show that even with 85% of 10RM for 10 repetitions a significant hypotensive effect occurred regardless of the surface where the training (SST and UST) occurred. It is also important to highlight that for all exercises the SST absolute load was higher compared to absolute UST load, even with the equalized intensity acquired at the 10RM tests for each specific surface situation. Another distinguishing methodological fact of our experiment is that the sample was composed exclusively of women.

It is also important to acknowledge that the other experiments did not find similar post-exercise hypotension (16). Rodrigues et al. (16) did not find any hypotensive responses in SBP and DBP after two different methods of ST (traditional and circuit) with loads of 70% of 1RM. No post-exercise responses were found compared to the control and the pre-measurement for up to 90-min. Rodriguez et al. (16) suggest that blood pressure variations may require recruiting larger muscle groups such as the lower limbs.

Rodriguez and colleagues (16) indicated that exercising the upper limbs using a low volume regimen was not sufficient to trigger a significant hypotensive post-exercise response. Their data suggest that, in particular, SBP reductions are strongly related to a higher training intensities and a large muscle group exertion (15). In our study, it was clear that even with similar intensities for SST and UST, the different absolute load seemed to be a crucial factor for the longer duration of the decrease in SBP.

Although there is a connection between the cause and effect of post-exercise hypotensive, it is yet to be fully comprehended. Senetiko and colleagues (18) have worked at clarifying the mechanisms of the relationship between the two by comparing the hypotensive effect on sedentary and trained men and women. There is a strong possibility that this effect is related to the baroreflex compensation mechanism that in sum redefines the lower values obtained during the post-exercise situation, thus resulting in a decreased cardiac output and sympathetic activation. Additionally, a higher nitric oxide release and hyperemia occurs as a function of the muscle contraction (14). These factors are no doubt involved in the decrease in blood pressure at rest during a post-exercise situation. Furthermore, an important factor to be taken into consideration is that the reduction in vascular resistance, which can be triggered by different endothelial substances (regardless of the behavior of cardiac output and sympathetic neural activity) (12).

CONCLUSIONS

This study contributes to the growing body of knowledge that different forms of strength training such as the SST and the UST may produce a post-exercise hypotension. Apparently, both the SST as UST can be applied as non-pharmacological strategies to help aid in the control and/or prevention of hypertension. However, it is important to emphasize that
although the magnitude of the outcome were similar, the hypotensive duration effect was prolonged with the SST. This phenomenon apparently resulted from the higher absolute load, regardless of the equalized intensity, performed during the UST protocol. In our perspective, these results add significantly to the understanding of the training prescription that focuses on specific populations.

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