

## Effect of Different Concurrent Training Methods on Post-Exercise Hypotension in Borderline Hypertensive Women

<sup>1</sup>Sedigheh Hosseinpour Delavar and <sup>2</sup>Hassan Faraji

<sup>1</sup>Department of Physical Education and Sport Science,  
Islamic Azad University, Kermanshah Branch, Kermanshah, Iran

<sup>2</sup>Department of Physical Education and Sport Science,  
Islamic Azad University, Marivan Branch, Marivan, Iran

**Abstract:** The purpose of this study was to evaluate the post-exercise blood pressure responses to two different methods of concurrent training [resistance before endurance exercise (RBE) vs endurance before resistance exercise (EBR)] based on the different sequence. Ten borderline hypertension women ( $37.6 \pm 6.5$  years;  $80.8 \pm 6.2$  kg;  $170.2 \pm 6.9$  cm) participated in this study. Participants were performed order three sessions on distinct days. In RBE, participations performed resistance exercise as 3 sets of 12 repetitions of the 5 exercises, with a workload corresponding to 60% of 1RM and then ran on the treadmill for 22 min at 60% of  $HR_{max}$ . In contrast, the subjects performed reverse sequence at similar exercise characteristic in EBR session. The participants rested in a non-exercise control trial (C). In each session the blood pressure were measured before and after exercise at 15, 30, 60, 90 and 120 min, also at 4, 5 and 6 hours of recovery. Blood pressure responses were not significant altered during the C trial. A significant drop of systolic blood pressure was observed after both RBE and EBR compared to pre-exercise levels at all time points. However, systolic blood pressure was significantly lower in EBR vs. RBE at 5<sup>th</sup> and 6<sup>th</sup> hours of recovery. Diastolic blood pressure was significant decreased similarly after both EBR and RBE for 90 min. In conclusion, concurrent exercise in both form of EBR or RBE evoked post exercise hypotension up to late the afternoon. Also, concurrent exercise in the EBR vs. RBE form resulted in a greater post-exercise hypotension for systolic blood pressure.

**Key words:** Concurrent Training • Blood Pressure • Post-Exercise Hypotension • Exercise Sequence

### INTRODUCTION

Hypertension can increase risk of cardiac, renal, cerebral event and other pathologic conditions in life [1, 2]. Although it has been known that chronic exercise training can result in lower resting blood pressure in hypertensive individuals [3], recent studies have indicated that following a single bout of exercise there is a reduction in systolic and/or diastolic blood pressure which has been termed post-exercise hypotension (PEH) [4]. PEH is widely investigated because of its importance for non-pharmacological and less expensive the treatment and prevention of arterial hypertension [3]. PEH phenomenon can be detected in normotensive, borderline hypertensive and hypertensive individuals (approximately 8/9 mmHg, 14/9 mmHg and 10/7 mmHg, respectively) [5]. The mechanism or mechanisms

responsible for the post-exercise hypotensive response are unclear. However, it is thought that PEH is due to reductions in peripheral vascular resistance in response to exercise [3, 5].

Most of the studies have reported PEH following endurance and/or resistance exercises (separately) in normotensive and hypertensive individuals [5-11]. Some data also showed that PEH can induced by exercise intensity or duration, age group and level of rest blood pressure [7, 8, 12-14]. Unfortunately, there are few studies in the literature regarding the hypotensive effects of concurrent exercise, especially in borderline hypertensive individuals. Concurrent training, in which resistance and endurance exercise are combined or included in the same training sessions or program, has been studied in the search for new methods to interfere with reduce rates of overweight, development of strength and aerobic

capacity, also to cardiovascular adaptations [15-17]. Only one study, however, has investigated hypotensive response after combined 30 min of arm and leg ergometry [18]. If concurrent training is to be used as a non-pharmacological intervention in the management of hypertension, more knowledge is required about the different characteristics of the exercise required to evoke PEH, especially the sequence of training [resistance before endurance (RBE) or endurance before resistance (EBR) exercise].

Therefore, the purpose of this study was to investigate the effect of two different methods of concurrent training based on the different sequence on the PEH responses in borderline hypertensive women.

## MATERIALS AND METHODS

**Subjects:** Ten women ( $37.6 \pm 6.5$  years;  $80.8 \pm 6.2$  kg;  $170.2 \pm 6.9$  cm) with borderline hypertension and at least 6 months of previous experience in exercise training volunteered to participate in this study. The subjects were limited to female to reduce variation in blood pressure response to the exercise [19]. During previous medical screening (four measurements), the participations were classified as borderline hypertension ( $135 < \text{systolic blood pressure} < 150$  and/or  $85 < \text{diastolic blood pressure} < 95$  mmHg) according to ACSM's position stand on blood pressure [3]. The university's institutional review board evaluated and approved all aspects of this research protocol. Complete advice about possible risks and discomfort was given to the participants and all of them give their written informed consent to participate. Two subjects were taken beta-blockers agents. Participants were instructed not to exercise 48 h prior to the exercise trials and to maintain similar activities and meal patterns.

**Exercise Protocols:** The participations carried out three experimental sessions, which occurred at 9:00 AM, on distinct days and with a minimum of 72 h intervals: (a) resistance before endurance exercise (treadmill running) (RBE), (b) endurance before resistance exercise (EBR) and (c) a control session without exercise (C). In each session (RBE and EBR or C), the systolic and diastolic blood pressure were measured before (resting) and after exercise at 15, 30, 60, 90 and 120 min in a sitting position on chair. These blood pressure measurements were also performed after lunch (with similar contain) at 4,

5 and 6 hours of recovery. For each session, resting systolic and diastolic blood pressure were obtained every 5 min during 20 min in a seated position and averaged to represent the resting value. In the afternoon, they participations were allowed to walk or sit at the laboratory. However, all afternoon's measurements also were performed in the sitting position (after 10 min sit). Blood pressure was recorded by the same observer in all exercise trials, using a standard mercury sphygmomanometer (Yamasu, Japan). HR was monitored by Polar (S810). An experienced appraiser performed the measurements in the present study.

Before the first of these three sessions, lower and upper body maximal strength was assessed by using one repetition maximum (1RM). The subjects' 1RM test was completed for each of the 5 resistance exercises employed in the study and 60% of 1RM selected as represented load used in testing sessions. On a separate visit, subjects undertook a 60 min familiarization session in which they completed three sets of 15 repetitions of 5 different resistance exercises at 60% of 1RM. The order of exercises was as follows: shoulder press, lat pull-down, leg press, knee extension and leg curl. Then subjects were divided to RBE and EBR groups in a randomized design.

In subsequent sessions, RBE subjects performed resistance exercise as 3 sets of 12 repetitions of the 5 exercises cited above, with a workload corresponding to 60% of 1RM and an interval of 50s between the sets and 60s between the exercises and then ran on the treadmill for 22 min at 60% of  $HR_{max}$  (calculated from 220-age equation). In the separate session, EBR subjects performed reverse sequence but with similar exercise characteristic (for exercise duration or intensity). The treadmill velocity and heart rate were controlled continually during the exercise.

**Control Session:** To determine any potential diurnal variations in blood pressure, the participants performed a non-exercise control © trial. During this trial, the participants were remained resting (at the period corresponding to exercise). Blood pressure measurements were performed at the same moments of the exercise sessions.

All participants ate a light and similar lunch and were instructed to avoid physical exercise and alcohol for at least the prior 48 h and to avoid smoking, alcohol and medications for 24 h. Ambient temperature was controlled between 22 and 25°C.

**Statistical Analyses:** Data were analyzed using SPSS version 14.0 (SPSS Inc., Chicago, IL, USA). Baseline levels in different exercise trials were analyzed by one-way analysis of variance for repeated measures. The two-way repeated measure of ANOVA (3 trials  $\times$  3 times) was used to measure the effect of the different interventions and the time related to the intervention on blood pressure values. Data are expressed as means  $\pm$  SD and statistical significance was set at  $P < 0.05$ .

## RESULTS

Figure 1. Shows the systolic and diastolic blood pressure responses on the three experimental sessions (RBE, EBR and C). Baseline systolic and diastolic blood pressures were similar in all experimental trials.

During control session, systolic blood pressure ( $+1.8 \pm 4$  mmHg) and diastolic blood pressure ( $+0.7 \pm 3$  mmHg), did not change significantly.

In relation to pre-exercise resting (RBE:  $138.4 \pm 11$ ; EBR:  $135.6 \pm 12$  mmHg), a significant ( $P < 0.05$ ) PEH of systolic blood pressure was observed

after both RBE ( $-11.6 \pm 8$  mmHg) and EBR ( $-12.5 \pm 9$  mmHg) at all time points. However, systolic blood pressure was significantly lower in EBR vs. RBE at 5<sup>th</sup> and 6<sup>th</sup> hours (5<sup>th</sup> h:  $121.7 \pm 10$  vs.  $128.9 \pm 11$  mmHg; and 6<sup>th</sup> hour:  $121.1 \pm 8$  vs.  $129.2 \pm 10$  mmHg, respectively) of recovery (see Figure 1).

A significant PEH of diastolic blood pressure was observed similarly after both RBE ( $-10.5 \pm 9$  mmHg) and EBR ( $-9.8 \pm 7$  mmHg) for 90 min ( $P < 0.05$ ) compared to pre-exercise resting levels (RBE:  $83.3 \pm 7$ ; EBR:  $82.4 \pm 8$  mmHg).

## DISCUSSION

Hypertension causes the heart to work harder by generating greater pressure to drive the blood throughout the body. This condition is associated with the development of coronary artery disease, acute myocardial infarction, kidney insufficiency and other pathologic conditions [20, 21]. The benefits of exercise raining on the cardiovascular system are well-documented [22]. Recently, attention of some studies not focused only on

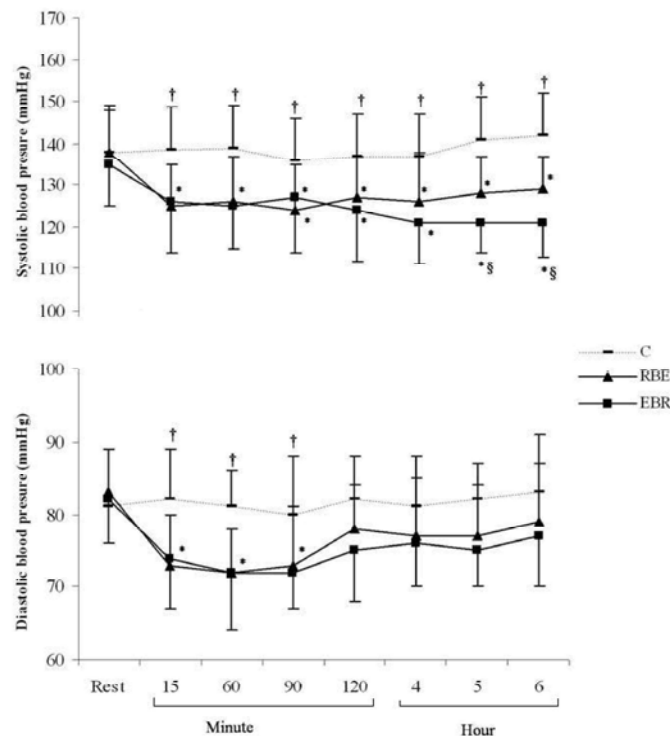


Fig. 1: Changes in systolic and diastolic blood pressure during the recovery period of resistance before endurance exercise (RBE), endurance before resistance exercise (EBR) and control session (C)

\* Significant different ( $p < 0.05$ ) vs. rest

† Significant different vs. RBE or EBR

§ Significant different vs. RBE

the cardiovascular benefits of physical training, but also on the effects of one acute exercise session [23]. The results of previous research have shown that, following a single bout of exercise, there is a reduction in blood pressure which has been termed PEH. The mechanism or mechanisms responsible for the post-exercise hypotensive response are not yet known; it is thought, however, that PEH is due to reductions in peripheral vascular resistance [3, 5]. Although the mechanisms for the persistent vasodilation underlying PEH are poorly understood, exercise-mediated alterations in sympathetic nervous system function and vasculature responsiveness and baroreflex resetting to a lowering operating blood pressure have been implicated [3]. However, it is important to assess the cardiovascular responses associated with a given exercise program to define better prescription strategies for subjects with cardiovascular disease [24].

We compared two concurrent training protocols that differed exercise sequence on PEH among ten borderline hypertension women. The present study is the first to examine the influence of the combined resistance and endurance exercise sequencing order on changes in PEH. The mean findings were that a PEH was observed after both RBE ( $-11.6 \pm 8$  mmHg) and EBR ( $-12.5 \pm 9$  mmHg) during 6 h after the exercises compared to the C session. Lowering blood pressure, even at small levels (2 mmHg) in systolic and diastolic blood pressure, decrease the risk of stroke by 14% and 17% and the risk of coronary artery disease by 9% and 6%, respectively [25]. Our results indicated moderate concurrent exercise could be effective on reduce the recovery blood pressure, even during day time, in people with borderline hypertension.

During the C session, subjects' blood pressure levels rose ( $+2.5 \pm 4$  mmHg) at afternoon compared to rest levels. Although this increase not statistically significant, it is possible that this phenomenon has been due to the higher activity of the sympathetic nervous system and the higher levels of catecholamine observed at the end of afternoon [26]. However, despite any influence of the diurnal variations in blood pressure, it becomes clear from the current study that concurrent exercise of either RBE or EBR were able to attenuate the subjects' blood pressure over the afternoon.

Some studies failed to induce a hypotensive response in either systolic or diastolic blood pressure following resistance exercise last to 90 min [27, 28] or 24 h monitoring [29, 30]. However, it is possible to say that if resistance exercise be combined with at least 22 min endurance exercise (in RBE or EBR models), the PEH can be observed, as we employed.

Although both systolic and diastolic blood pressures were decreased in the current investigation, the duration of the drop was longer systolic blood pressure. It is generally was found that systolic blood pressure demonstrates the larger decrement as well as the longest duration [31, 32].

One unexpected finding of this study was exercise method differentially modulated PEH depending on the duration of the observation. After the 4h of recovery, systolic blood pressure drop was greater for EBR vs RBE session up to last blood pressure measurement. Reasons for these observations are unclear, but may reside in the proposed mechanisms for PEH which include exercised induced alterations in baroreceptor function, i.e. either a shift to a lower blood pressure operating point or an increased responsiveness to changes in blood pressure during the post-exercise period [33]. It is conceivable that exercise induced alterations in baroreceptor function contributed similar to the lowering blood pressure of either RBE or EBR initially; however, over time other PEH mechanisms became operative that augmented the blood pressure benefits of EBR for the remainder of the afternoon hours.

Previous investigators reported that conducting endurance training before resistance training in a concurrent exercise protocol (chronic exercise) improved cardiovascular adaptations more than the reverse sequence [16]. In general, this convergence of results for both acute and chronic concurrent exercise is noteworthy and suggests that performing endurance before resistance exercise in a concurrent protocol can be affective on cardiovascular system more than the reverse sequence. However, further work will be needed to investigate this possibility.

Two subjects were using beta-blockers agents during study course. However, the medication intake was the same in all experimental sessions and it is verified that exercise associated to medications, such as beta-blockers, did not impair PEH [34].

This is the first investigation about PEH following concurrent endurance and resistance exercise in borderline hypertension women. It is clear that future studies, should address the effect of different characteristics (i.e. intensity and volume/duration) of the concurrent exercise on post-exercise cardiovascular responses for long periods (24h).

## CONCLUSIONS

Concurrent exercise in both form of RBE or EBR evoked PEH up to late the afternoon, when compared to the control day without exercise.

However, concurrent exercise in the EBR form resulted in a greater PEH for systolic blood pressure at late the afternoon. Nonetheless, the concurrent exercise as combined training may contribute to non-pharmacological treatment and prevention of hypertension and preventing risk factors associated to cardiovascular diseases.

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