Original article

Strength training and blood pressure in normotensive women: the effects of the conjugate method

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Summary

Objective: Analyze the effect of conjugated strength training method for lower limbs exercises on arterial blood pressure of normotensive women.

Material and methods: Experimental study attending 10 normotensive women (30.2±5.2 years old; 68.4±5.5 kg, 1.65±0.04 m, BMI 25.04±2.63, systolic blood pressure at rest: 121±5.2 mmHg; dyastolic blood pressure at rest: 74.8±6.5 mmHg). After anthropometric evaluation, 10 repetition maximum tests, volunteers were submitted to training, composed by 3 conjugated sets, respectively at Leg Press 45º, Knee flexion machine, knee extension machine, with load of 70% of 10 repetition maximum. The speed of concentric and excentric phases was of 2" in each exercise, and rest interval of 3' between sets'. Arterial blood pressure admeasurement were held through the auscultatory method at distinct moments: after 10' resting; immediately post-exercise; and every 20' post-exercise for 60'.

Results: Changes were observed for systolic blood pressure with increase between resting and post-exercise and reduction between moments 20', 40' and 60' (F= 66.654; p= 0.0001). There were changes also for diastolic blood pressure between resting and post-exercise moment (F= 15.258; p= 0.0001), however without changes when comparing moments 20', 40' and 60' and post-exercise.

Conclusion: The conjugate method was able to generate post-exercise hypotension only for systolic blood pressure.

Key words:
Physical exercise. Blood pressure. Post-exercise hypotension and strength training.

Entrenamiento de fuerza y presión arterial en mujeres normotensas: efectos del método conjugado

Resumen

Objetivo: Analizar el efecto del método conjugado de entrenamiento de fuerza en ejercicios para miembros inferiores sobre la presión arterial de mujeres normotensas.

Material y método: Se realizó un estudio experimental en el cual participaron 10 mujeres normotensas (30,2 ± 5,2 años, 68,4 ± 5,5 kg, 1,65 ± 0,04 m, IMC 25,04 ± 2,63, presión arterial sistólica en reposo: 121 ± 5,2 mmHg, presión arterial diastólica en reposo: 74,8 ± 6,5 mmHg). Después de la valoración antropométrica y los test de 10 repeticiones máximas, las voluntarias fueron sometidas al entrenamiento que consistió en 3 series conjugadas, respectivamente, entre los ejercicios de máquina Leg Press 45º, Leg Extension y Leg Curl, con sobrecarga de 70% en 10 repeticiones máximas. La velocidad de ejecución de las fases concéntricas y excéntricas fue de 2" en cada ejercicio, y los intervalos entre las series fueron de 3'. Las mediciones de la presión arterial se realizaron por medio del método auscultatório en distintos momentos: después de 10' en reposo; inmediatamente después del ejercicio; y cada 20' después del ejercicio durante 60'.

Resultados: Se observaron cambios en la presión arterial sistólica con elevación entre los momentos de reposo y post-ejercicio y reducción entre los momentos 20', 40' y 60' (F= 66,654; p= 0,0001). Se observaron cambios en la presión arterial diastólica entre el momento de reposo y el momento post-ejercicio (F= 15,258, p= 0,0001), pero sin alteración de la variable en la comparación entre los momentos 20', 40' y 60' y el momento post-ejercicio.

Conclusión: El método conjugado fue capaz de generar la hipotensión post-ejercicio sólo para la presión arterial sistólica.

Palabras clave:
Ejercicio físico. Presión arterial. Hipotensión post-ejercicio. Entrenamiento de fuerza.

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Introduction

Hypertension (HT) is a multifactorial clinical condition characterised by persistently high arterial blood pressure (BP). It is often associated with functional and/or structural damage to the target organs (heart, brain, kidneys and blood vessels), with the consequent increase in the risk of fatal and non-fatal cardiovascular events[1].

HT is a highly prevalent disease, considered a global public health problem due to the difficulty involved in controlling it. Some cases are asymptomatic, meaning that it is often neither diagnosed nor treated[2].

Reducing BP can prevent cardiovascular diseases, thereby improving the quality of life of the population[3]. Regular exercise is recommended to prevent and treat these and the risk factors for them, as well as other chronic diseases[4].

One common type of exercise is strength training (ST), where adaptation of the methodological variables prescribed, such as the order of the exercises, the interval between sets and exercises, the number of sets and repetitions, the overload and the training method, can trigger different physiological responses which can affect BP behaviour after a training session[5].

One of the numerous methods available is the conjugate method, which consists of performing more than one exercise for the same muscle group or different muscles groups in sequence and without a recovery interval in between during a set in order to increase the time during which the target muscles are under tension[6].

A single ST session can reduce BP for a number of hours[7]. This effect is known as post-exercise hypotension (PEH). The blood pressure levels during recovery are lower than those obtained at rest before starting training[8] or those registered on days without any physical exercise[9].

There is evidence to suggest that long-term BP reductions resulting from exercise programmes are due to the sum of the acute hypotensive effects of training sessions[10]. However, doubts remain about the methods used in ST regarding the occurrence and duration of the response, and the physiological mechanisms associated with PEH[11].

Of the different types of ST available, the evidence focusing on the hypotensive responses observed is limited when it comes to the conjugate methods, these normally being used to enhance strength or muscle hypertrophy.

In view of the paucity of data on the PEH induced by the conjugate method, research into the hypotensive effect of ST involving the method in question is more than warranted. The present study, therefore, aims to analyse the effect of the conjugate ST method for lower limbs on the BP of normotensive women.

Materials and method

Sample

Ten female volunteers (30.2 ± 5.2 years old) who met the following inclusion criteria: normotensive without the use of beta-blockers, angiotensin converting enzyme (ACE) inhibitors, diuretics, corticosteroids or Ca^2 + channel blockers, who had done ST sessions lasting over 60 minutes at least five days a week for over 6 months or with a suitable Physical Activity Questionnaire Readiness (PAR-Q)[12] result; and the following exclusion criteria: sufferers from degenerative or metabolic diseases, those with musculoskeletal injuries preventing them from performing the exercises, those with cardiovascular dysfunctions and users of ergogenic substances.

The *Free and Informed Consent* document (TCLE) for participation in research involving human beings was signed, in accordance with Resolution 466/2012 of the National Health Council (Brazil). The project for this study was submitted to the Research Ethics Committee of the Naval Hospital Marcilio Dias / Rio de Janeiro / Brazil and was approved under protocol number 1581498/2016.

Experimental development

Each volunteer came three times with a minimum interval of 48 hours between each visit. In the first session, the participants were informed about the data collection procedures and the intervention, answered the PAR-Q, were measured anthropometrically and did the 10RM tests. In the second session, they did the 10RM retests. In the third session, they did the ST and their haemodynamic responses were compared before and after it.

Height was measured using a Sanny® ES2020 stadiometer (Brazil) with a maximum measurement of 2.1 m and 0,001 m precision. Body mass (BM) was registered with 110CH Welmy® mechanical scales (Brazil) with a 150 kg limit and 100 g precision. The body mass index (BMI) was calculated using the ratio between BM and the square of height. The anthropometric measurements were taken following the recommendations of the International Standards for Anthropometric Assessment (ISAK)[13].

10RM tests were chosen to prescribe the ST intensity[14]. These were conducted on the same day on a Technogym® 45º Leg Press (Italy) and Life Fitness® Leg Extension and Leg Curl equipment (USA).

The warm-up consisted of 15 repetitions with 50% overload, estimated according to the training weight. Three minutes later, the first of the three attempts at each movement was carried out. The initial overload was estimated according to the overload used in the volunteers' training sessions.

The tests stopped when voluntary concentric failure occurred at 10RM. The movement execution speed was 2 seconds for each phase (concentric / eccentric) without any interval allowed in between these.

If the overload for 10RM was not reached after 3 attempts, the test was cancelled and performed on a non-consecutive day. The intervals between attempts for each exercise were set at 5 minutes to recover. After 3 attempts at an exercise at 10RM, 10 minute recovery intervals were set before moving on to the test for the next exercise in order to minimise premature fatigue.

Following the same protocols, the volunteers were subjected to strength retests for the same exercises in order to verify the reproducibility of the overloads obtained[15] with a minimum interval of 48 hours.

The greatest overload reached in the two tests with a difference of less than 5% between them was taken as 10RM. If the difference exceeded that percentage, new tests and retests were scheduled.

Participants were asked not to exercise or consume stimulants in the 24 hours preceding the training session and data collection. The tests and retests were held at times similar to those at which the volunteers usually trained.

In the ST session, the participants warmed up with 15 repetitions on the 45º Leg Press with an overload of 50% 10RM. 3 sets were completed in the three minutes following warm-up, consisting of the 45º Leg Press, Leg Curl and Leg Extension with an overload of 70% 10RM and without recovery intervals between them, avoiding the Valsalva manoeuvre. The movement execution speed was the same as in the tests and retests. The intervals between each set lasted 3 minutes. In the third set, the cuff of a sphygmomanometer was fitted onto the volunteer's left arms to do the exercise on the equipment.

BP was recorded using a digital Microlife® 3BTO BP-A sphygmomanometer (Switzerland), approved by both the British Hypertension Society (BHS) and the American Heart Association (AHA).

BP was measured at different times: at rest before the ST (in an empty room after being in supine position for 10 minutes); post-exercise (immediately after the third set of ST on the Leg Extension equipment itself with feet uncrossed and hands supine); and at rest after the exercise (20, 40 and 60 minutes after the training session in the same place and in the same positions in which the BP measurements were taken at rest before the exercise).

Statistical analysis

The descriptive statistics focus on the measures of central tendency and dispersion, and the Shapiro-Wilk test. The results obtained were subjected to a One-way ANOVA, followed by Tukey's post-hoc test. The data were processed using the Statistical Package for Social Sciences (SPSS 18.0, Chicago, USA). The level of significance was set at $p \leq 0.05$.

Results

Table 1 shows the volunteers' anthropometric characteristics and the results of the Shapiro-Wilk test for the variables.

Figure 1 shows the participants' systolic blood pressure (SBP) and diastolic blood pressure (DBP) at different times: at rest before the ST, immediately after the ST session (post-exercise) and over the next 60 minutes (20', 40' and 60' after the session).

Changes were observed in SBP ($F = 66.654$, $p = 0.0001$), which rose between at rest before exercise and immediately after exercise, and then dropped 20', 40' and 60' afterwards compared to both.

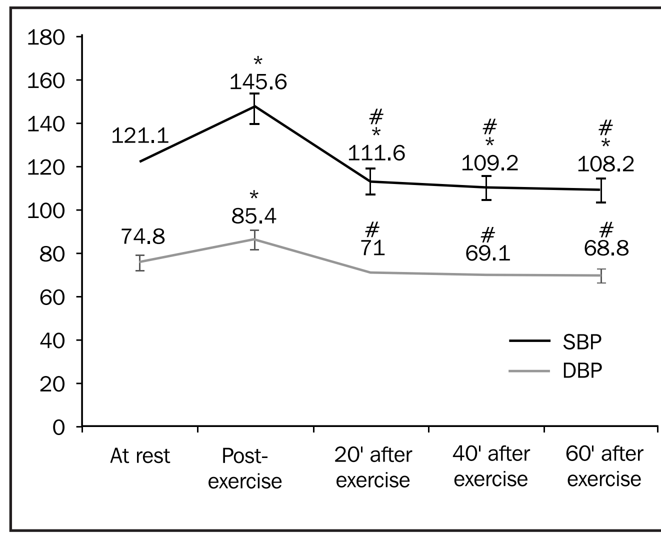
DBP changed ($F = 15.258$, $p = 0.0001$) between at rest before exercise and immediately after exercise, but no significant drop in the variable was noted on comparing 20', 40'and 60' post exercise with at rest beforehand.

Table 1. Anthropometric characteristics.

n = 10	Age (years)	TBM (kg)	Height (m)	BMI (kg/m²)
Mean	30.2	68.4	1.65	25.04
sd	5.2	5.5	0.04	2.63
Minimum	22	61.7	1.60	22.12
Maximum	38	76.3	1.74	28.98
SW (p-value)	0.75	0.26	0.34	0.10

TBM: total body mass; BMI: body mass index; sd: standard deviation; SW (p-value): Shapiro-Wilk normality test.

Figure 1. Analysis of SBP and DBP at rest and after exercise.



SBP: systolic blood pressure; DBP: diastolic blood pressure; * significant difference in relation to rest ($p < 0.05$): # significant difference in relation to post-exercise ($p < 0.05$).

Discussion

The present study aimed to analyse the effect of the conjugate ST method for lower limbs on the BP of normotensive women. ST stimulates the production of substances which regulate the body, including nitric oxide, which is secreted in the endothelium and is responsible for vasodilation, improving blood circulation and the metabolic functions needed to recover from exercise[16].

The increased vasodilation after training leads to a drop in BP, acting for up to 24 hours in hypertense individuals. This means that long-term exposure to PEH can reduce BP at rest by diminishing peripheral vascular resistance, that is to say, continuous dilation of the blood vessels, thereby facilitating blood circulation[8].

In addition to nitric oxide, other substances with a hypotensive effect are also released through exercise, such as prostaglandins, adenosine, potassium, lactate, bradykinin and vasopressin[17].

This research saw an increase in both SBP and DBP immediately after exercise compared to at rest beforehand. This can be explained by the variables which contribute to increasing BP and manifest themselves during high-intensity exercise, such as the activation of chemoreceptors as a result of peripheral fatigue[18].

However, the results showed a drop in SBP as of 20 minutes post-exercise which lasted until 60 minutes later. The hypotensive effect for DBP was not reached in the 60 minutes after exercise. Kelley and Kelley[19], however, saw drops of approximately 3 mmHg in the group participating in their ST programme. These reductions were equivalent to reductions of 2% and 4% for SBP and DBP, respectively. Although they may appear modest, from a clinical standpoint such modifications in hypertensive individuals are sufficient to reduce the risk of heart disease by 5-9%, the risk of stroke by 8 to 14% and the risk of death by 4%.

Kenney and Seals[20] reported that BP responses may be differ between normotensive and hypertensive individuals, since PEH may be associated with the health status of the individual. They showed that blood pressure fell more in hypertensive patients, in whom the drop in SBP and DBP after exercise varied from 18 mmHg to 20 mmHg and from 7 mmHg to 9 mmHg, respectively. In normotensive individuals, the reduction of the levels of the variables was less relevant (SBP: 8 mmHg to 10 mmHg; DBP: 3 mmHg a 5 mmHg), similar to the results obtained in this study.

In line with the findings of this research, O'Connor *et al*.[21], who analysed the blood pressure responses of 14 female volunteers between 30 minutes and 2 hours after an ST session consisting of 3 sets at varying intensities on leg extension, leg curl, pull down, chest press, shoulder press and abdominal curl equipment, observed higher SBP values, but no reduction in DBP.

The experiment conducted by Granados and Herrera[22] analysed the hypotensive effect of completing two 30-minute aerobic exercise sessions on a treadmill (one at an intensity of 50% HRreserve and the other at 70% HRreserve) on 10 men. PEH in SBP for 50% HRreserve was reached and maintained for the first 30 minutes, while PEH was observed as of 10 minutes until 60 minutes for 70% HRreserve. No significant difference, however, was observed for DBP.

According to Brum *et al*.[23] PEH in normotensive subjects after ST is due to the drop in cardiac output as a result of the decrease in systolic volume, the drop not being compensated for by increased peripheral vascular resistance. This mechanism would seem to be the same for both low- and high-intensity exercise, but when a longer period after high-intensity exercise is considered, peripheral vascular resistance at the start of recovery partially compensates for the drop in cardiac output, preventing reduction in DBP, but not in SBP.

Meanwhile, investigating the blood pressure responses of 6 physical education students after ST consisting of 3 sets at 70% 10RM with free weights, Hill *et al*.[24] saw a significant drop in DBP after exertion over 60 minutes without noting any change in SBP.

The results appear contradictory, maybe because there is not a single benchmark for the way in which ST is prescribed. According to Lizardo and Simões[25], there is still not enough information on intensity, the muscle groups involved, body segments and the magnitude and duration of PEH, indicating the need to define the characteristics of exercise, the method used and under what circumstances the phenomenon may occur, thereby justifying future studies.

In conclusion, the ST session using the conjugate method as prescribed for this study led to a drop in SBP in the period monitored following exercise. This was not true for DBP.

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Conflict of Interests

The authors declare that they are not subject to any type of conflict of interest.

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