CARDIOVASCULAR AND STRENGTH ADAPTATIONS IN CONCURRENT TRAINING IN HYPERTENSIVE WOMEN

ADAPTAÇÕES CARDIOVASCULARES E DE FORÇA NO TREINAMENTO CONCORRENTE EM MULHERES HIPERTENSAS

ADAPTACIONES CARDIOVASCULARES Y DE FUERZA EN EL ENTRENAMIENTO CONCURRENTE EN MUJERES HIPERTENSAS

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ABSTRACT

Introduction: Physical exercise has been recommended as a non-pharmacological strategy for preventing and controlling hypertension. Objective: To verify chronic cardiovascular and muscle strength adaptations in hypertensive women who underwent 12 weeks of concurrent training (CT) in different orders. Methods: Twenty hypertensive women were randomly assigned into 2 groups: resistance exercise-endurance group (REE; 56.00 ± 5.20 years; 78.95 ± 8.28 kg; 155.10 ± 5.30 cm; 33.00 ± 5.30 kg.m^{-2}) and endurance-resistance exercise group (ERE; 57.10 ± 13.38 years; 76.56 ± 18.87 kg; 155.50 ± 8.18 cm; 31.41 ± 5.84 kg.m^{-2}). The endurance exercise was composed of 3 sets of 4 exercises, with 8-RM loads with a 90-second break between sets and exercises. The resistance exercise lasted for 25 minutes and was of progressive intensity. Muscle strength (8-RM), systolic and diastolic blood pressure, heart rate, and double product were assessed pre- and post-exercise. Results: The ANOVA showed significant increases in strength for all exercises (p <0.0001) regardless of the order of the concurrent training (bench press, p = 0.680; leg press, p = 0.244; seated row, p = 0.668; and leg extension, p = 0.257). No significant differences in systolic (p = 0.074) and diastolic blood pressures (p = 0.064) were observed for different CT conditions. However, significant reductions in systolic (p = 0.0001) and diastolic blood pressures (p = 0.006) and double product (p = 0.006) only occurred in the REE group. Conclusion: Endurance training and resistance exercise promote significant muscle strength gains after 12 weeks of training regardless of CT order in hypertensive women. Beneficial cardiovascular responses (SBP, DBP, and RPP) were also observed when endurance training was initiated. ***Level of evidence I; Therapeutic Studies - Investigating Treatment Outcomes.***

Keywords: Muscle Strength; Arterial pressure; Hypotension; Physical fitness.

RESUMO

Introdução: O exercício físico tem sido recomendado como estratégia não farmacológica para prevenção e controle da hipertensão. Objetivo: Verificar as adaptações crônicas cardiovasculares e de força muscular em mulheres hipertensas submetidas a 12 semanas de treinamento concorrente (TC) em diferentes ordens. Métodos: Foram distribuídas aleatoriamente em dois grupos 20 mulheres hipertensas: grupo de treinamento de força-resistência (REE; 56,00 ± 5,20 anos; 78,95 ± 8,28 kg; 155,10 ± 5,30 cm; 33,00 ± 5,30 kg.m^{-2}) e grupo de exercícios de resistência-treinamento de força (ERE; 57,10 ± 13,38 anos; 76,56 ± 18,87 kg; 155,50 ± 8,18 cm; 31,41 ± 5,84 kg.m^{-2}). O treinamento de força foi composto por quatro exercícios, três séries, com cargas de 8-RM com 90 segundos de intervalo entre as séries e os exercícios. O exercício de resistência teve duração de 25 minutos com intensidade progressiva. Força muscular (8-RM), pressão arterial sistólica e diastólica, frequência cardíaca e duplo produto foram avaliados pré e pós-exercício. Resultados: ANOVA mostrou aumentos significativos de força para todos os exercícios (p < 0,0001), independente da ordem do treinamento concorrente (supino horizontal: p = 0,680; leg press: p = 0,244; remada sentada: p = 0,668; e cadeira extensora: p = 0,257). Para a pressão arterial sistólica (p = 0,074) e diastólica (p = 0,064), não foram verificadas diferenças significativas para diferentes condições de TC. No entanto, apenas em REE, houve redução significativa na pressão arterial sistólica (p = 0,0001), diastólica (p = 0,006) e duplo produto (p = 0,006). Conclusão: O treinamento de força e exercício de resistência promove ganhos de força muscular significativos em 12 semanas de treinamento, independentemente da ordem de realização, em mulheres hipertensas. Também foram observadas respostas benéficas cardiovasculares (SBP, DBP e RPP) quando iniciado pelo treinamento de força. ***Nível de evidência I; Estudos terapêuticos – investigando os resultados do tratamento.***

Descritores: *Força muscular; Pressão arterial; Hipotensão; Aptidão física.*

RESUMEN

Introducción: El ejercicio físico ha sido recomendado como estrategia no farmacológica para prevención y control de la hipertensión. Objetivo: Verificar las adaptaciones crónicas cardiovasculares y de fuerza muscular en mujeres hipertensas sometidas a 12 semanas de entrenamiento concurrente (EC) en diferentes órdenes. Métodos: Fueron distribuidas aleatoriamente en dos grupos veinte mujeres hipertensas: grupo de entrenamiento de fuerza-resistencia (REE, 56,00 ± 5,20 años; 78,95 ± 8,28 kg; 155,10 ± 5,30 cm; 33,00 ± 5,30 kg.m^{-2}) y grupo de ejercicios *de resistencia-entrenamiento de fuerza (ERE, 57,10 ± 13,38 años; 76,56 ± 18,87 kg; 155,50 ± 8,18 cm; 31,41 ± 5,84 kg.m^{-2}). El entrenamiento de fuerza fue compuesto por cuatro ejercicios, tres series, con cargas de 8-RM con 90 segundos de intervalo entre las series y ejercicios. El ejercicio de resistencia tuvo duración de 25 minutos con intensidad progresiva. La fuerza muscular (8-RM), la presión arterial sistólica y diastólica, la frecuencia cardíaca y el doble producto se evaluaron pre y post-ejercicio. Resultados: ANOVA mostró aumentos significativos de fuerza para todos los ejercicios (p < 0,0001), independiente del orden del entrenamiento concurrente (press de banca, p = 0,680; leg press, p = 0,244; remada sentada, p = 0,668; y silla extensora, p = 0,257). Para la presión arterial sistólica (p = 0,074) y diastólica (p = 0,064), no se verificaron diferencias significativas para diferentes condiciones de EC. Sin embargo, sólo en REE, hubo una reducción significativa en la presión arterial sistólica (p = 0,0001), diastólica (p = 0,006) y doble producto (p = 0,006). Conclusión: El entrenamiento de fuerza y ejercicio de resistencia promueve aumentos de fuerza muscular significativos en 12 semanas de entrenamiento, independiente del orden de realización, en mujeres hipertensas. También fueron observadas respuestas benéficas cardiovasculares (SBP, DBP y RPP) cuando se inicia por el entrenamiento de fuerza.* ***Nivel de evidencia I; Estudios terapéuticos – investigación de los resultados del tratamiento.***

Descriptores: *Fuerza muscular; Presión arterial; Hipotensión; Aptitud física.*

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INTRODUCTION

Systemic arterial hypertension is acknowledged to be an independent risk factor for stroke, coronary artery disease, and kidney failure.[1] Physical exercise has been recommended as a useful non-pharmacological strategy for preventing and controlling hypertension.[2] The American College of Sports Medicine[2] suggests that hypertensive adults should engage in a physical activity program involving endurance exercise at moderate to high intensities and resistance exercises.

According to Kesse et al.,[3] separate sessions of endurance and resistance exercise reduce blood pressure for prolonged periods, and those physical exercise methods can be adopted as a non-pharmacologic strategy for the treatment of hypertension. Perhaps that endurance training[4] and resistance exercise[5] promote reductions in systolic blood pressure (SBP) and diastolic blood pressure (DBP) in hypertensive individuals. More specifically, these both types of exercise can be combined as a strategy known as concurrent training (CT).

A well-planned CT can improve muscular strength and power without compromising the development of other physical capacities,[6] and was more is more effective than single-mode for endurance or resistance exercises in improving selected measures of physical fitness.[7] While CT can be adjuvant in an antihypertensive therapy[8-10] evidence regarding the influence of combined endurance and resistance exercise on resting blood pressure remains unclear.[11]

It appears to be well documented that distinct orders in CT do not influence muscle strength gains in healthy individuals.[12-14] However, the evidence is scarce regarding the effects of CT on blood pressure, for the hypertensive individuals.[15] Besides, little is known about the resulting chronical adjustments derived from the order (resistance/endurance vs. endurance/resistance) in which the exercise modalities are prescribed within the session. In fact, to the authors' knowledge, no study has investigated the cardiovascular and strength adaptations in hypertensive subjects that performed distinct CT orders.

Thus, the aim of this study was to verify the cardiovascular and whole-body strength adjustments in hypertensive women that performed 12 weeks of distinct CT order. The hypothesis is that regardless of CT order, subjects will benefit from cardiovascular and strength outcomes when compared to their previous condition.

METHODS

Twenty hypertensive women, sedentary for the previous two years, were selected to participate and were randomly assigned into 2 groups: 10 women belonging to the resistance exercise-endurance group (REE; 56.00 ± 5.20 years; 78.95 ± 8.28 kg; 155.10 ± 5.30 cm; 33.00 ± 5.30 kg.m-2) and 10 women for the endurance-resistance exercise group (ERE; 57.10 ± 13.38 years; 76.56 ± 18.87 kg; 155.50 ± 8.18 cm; 31.41 ± 5.84 kg.m-2). Subjects reported the use of different pharmacological compounds for hypertension control purposes. The distinct pharmacological mechanisms that were being used by the participants are described as follows: (a) angiotensin II receptor antagonist; (b) calcium channel antagonist; (c) competitive angiotensin I enzyme converting specific inhibitors; (d) beta-blocker; and (e) diuretic. Inclusion criteria were adopted to standardize subject selection: (a) woman, sedentary, and range age of 40 to 70 years; (b) with hypertension, thus proving through medical report; (c) not having any systemic (except hypertension), orthopedic and neurological pathologies previously diagnosed. Before data collection, all subjects answered "no" to all questions on the PAR-Q.[16] The study procedures had been already approved by the Federal University of Sergipe Ethics Committee (CAAE: 36925414.6.0000.5546). Participants read and signed the informed consent after being informed of the testing procedures according to the Declaration of Helsinki.

The anthropometric evaluation and preliminary procedures were performed in the following order: (a) interview anamnesis; (b) assessment of height, body mass, and BMI calculation. The heart rate (HR), SBP and DBP were assessed before and after intervention for both groups. All subjects were instructed to remain resting in a seated position for at least 10 minutes in low light and quiet environment. During all test procedures, room temperature was held constant at 20ºC. The HR, SBP, and DBP were assessed using an oscillometric device (Microlife BP 3AC1-1; Microlife Corporation, Berneck, Switzerland) which was previously validated.[17] The evaluation lasted 20 minutes, with values being recorded every five minutes. The mean value was used to characterize these values, and the rate pressure product (RPP) was calculated by multiplying HR and SBP.

Following the preliminary procedures, all volunteers performed a test and retest of 8-RM[18] for seated row machine (SR), leg press (LP), barbell bench press (BP), and seated leg extension (LE). All subjects were instructed to reach concentric failure. During the 8-RM tests, each subject performed a maximum of five attempts for each exercise with 10 minutes of rest between attempts. After the 8-RM determination, a 10-minute rest was given before the attempt for the following exercise. In a non-consecutive day, the retest was conducted with the inverted exercise order.

The following strategies were adopted to minimize error: (a) standard instructions were adopted; (b) subjects received guidance on exercise technique; (c) the mass of all plates and bars were determined by a precision scale. The warm-up before each test consisted of two sets of 12 repetitions at 40% of 8-RM.

After familiarization, the REE and ERE groups underwent 12 weeks of training (3 workout sessions/week). The resistance exercise program consisted of the following exercise sequence: SR, LP, BP, and LE in this order. Subjects performed three sets with 80% of the 8-RM load for eight repetitions with 90 seconds of rest between sets and exercises. There was no attempt to control the repetition speed. The endurance exercise lasted 25-minutes, and the intensity was obtained through the modified Borg scale.[19] A progressive intensity was implemented on following the weeks. All workout sessions were performed between 7, and 10 am. Adherence to the program was 100% for both training groups, and all the training sessions were supervised by a professional. The Pre- and the Post-training period was used to assess maximum strength to 8-RM and cardiovascular outputs (HR, SBP, DBP, and RPP). (Figure 1)

Statistical analysis

The results were presented by mean ± standard deviation (SD). All data was analyzed using a CT group (REE *vs* ERE) versus time (pre *vs* post) by 2x2 ANOVA. The Bonferroni *post-hoc* was applied for multiple comparisons. Additionally, the effect size (ESs) compared the post verifications *vs* pre (baseline) adopting thresholds proposed by Cohen.[20] The level of significance assumed was $p \leq 0.05$. All statistics were performed via SPSS software, version 22.0 (IBM, Inc, USA).

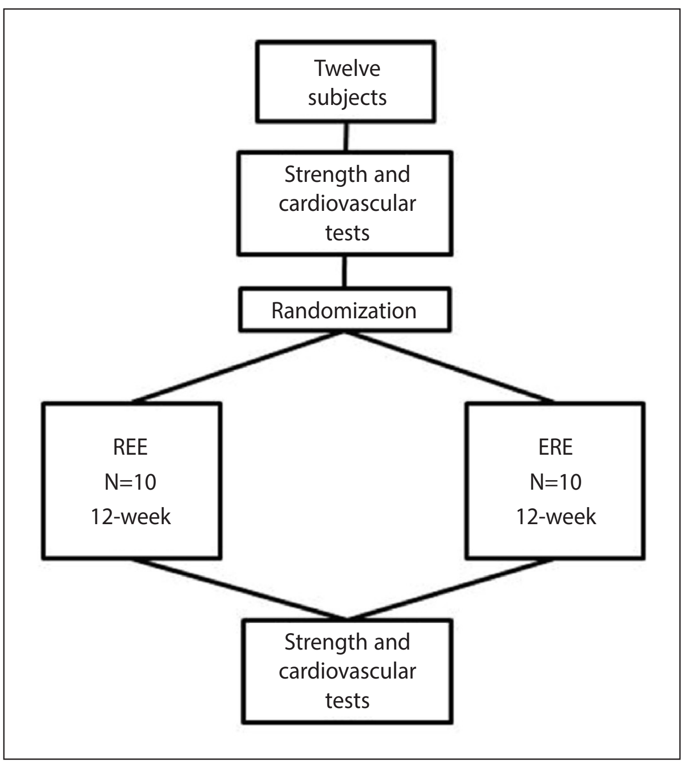

Figure 1. Experimental design.

RESULTS

For the BP exercise, no significant differences were found for interactions between time vs. CT condition (p = 0.877). For the time condition (pre *vs* post), significant differences were observed between Pre and Post-test values (p = 0,0001). Specifically, for REE (p = 0.0001) and ERE (p = 0.0001) strength gains were observed. No significant differences were found for different CT conditions (REE vs. ERE) (p = 0.680). The ESs presented large elevations in 8-RM BP values for REE (ESs = 2.90) and ERE (ESs = 4.59) in post-test.

The LP strength no interactions were found between time vs. CT condition (p = 0.778). In pre *vs* post comparison, significant difference (p = 0,0001) were observed. For REE (p = 0.0001) and ERE (p = 0.0001), significant strength gains were observed. No differences were found for different CT conditions (REE vs. ERE) (p = 0.244). The ESs showed a large effect in 8-RM BP for REE (ESs = 1.37) and ERE (ESs = 1.92) in post-tests.

For SR, no differences for interactions between time vs. CT condition (p = 0.586) were found. In time condition (pre *vs* post), significant differences were observed (p = 0,0001). The REE (p = 0.0001) and ERE (p = 0.0001) presented strength gains. No significant differences were observed for different CT conditions (REE vs. ERE) (p = 0.668). The ESs demonstrated a large increase in 8-RM BP values for REE (ESs = 3.37) and ERE (ESs = 2.52) in post-tests.

For LE, no interactions between time vs. CT condition (p = 0.127) were found. Significant differences were observed between pre and post-test (p = 0,0001). For REE (p = 0.0001) and ERE (p = 0.0001) strength gains were observed. No significant differences were found for different CT conditions (REE vs. ERE) (p = 0.257). The ESs presented a large elevation in 8-RM BP for REE (ESs = 3.37) and ERE (ESs = 2.52) in post-tests. (Figure 2)

For SBP, no differences were found for interactions between time vs. CT condition (p = 0.134). In time condition, significant differences were observed between pre and post-test values (p = 0,0001). For REE (p = 0.001) SBP reductions were observed, that did not occur in the ERE group (p = 0.351). No significant differences were observed for different CT conditions (p = 0.074). The ESs showed a moderate decrease in SBP values for REE (ESs = -0.76) and ERE (ESs = -0.67) in post-tests.

For the DBP, there were no differences between time vs. CT condition (p = 0.064). Significant differences were observed between pre vs. post-condition (p = 0.002). For REE, DBP reductions were observed (p = 0.006), that did not occur in the ERE group (p = 1.00). No significant differences were found between different CT conditions (REE vs. ERE; p = 0,068). The ESs showed a large reduction in DBP values for REE (ESs = -0.81) and a small effect was for ERE (ESs = -0.25) in post-tests.

For the HR, there was no differences for interactions between time vs. CT condition (p = 0.184). In pre vs post (p = 0.543) and CT condition (p = 0.708) no differences were found between pre and post-test. The ESs demonstrated a small decrease in HR values for REE (ESs = -0.24) and ERE (ESs = -0.23) in post-tests.

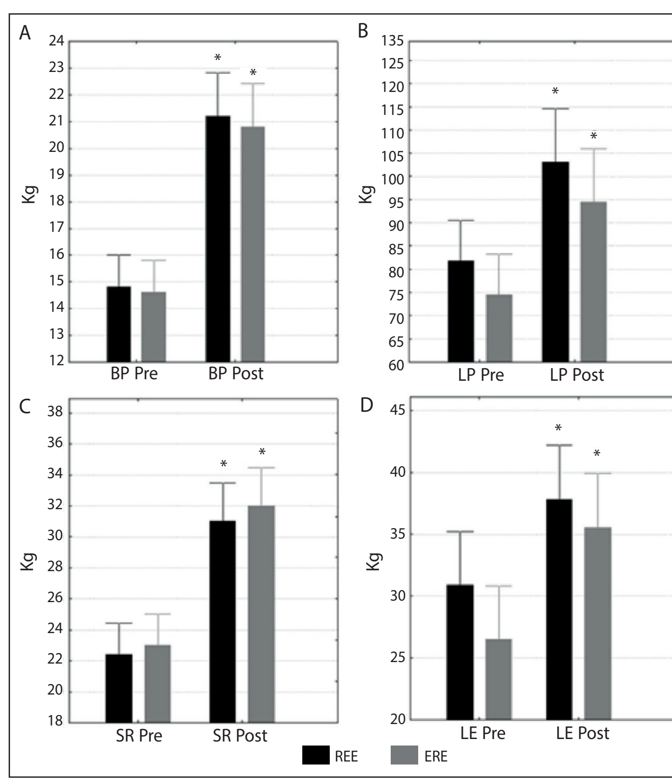

Figure 2. PRE to POST strength values (8-RM) for each exercise.

The RPP presented differences between time vs. CT condition (p = 0.036). For time comparisons, significant differences were found between pre and post-test (p = 0.005). For REE (p = 0.006) RPP reductions were observed, that did not occur in the ERE (p = 1.00). No significant differences were found for different CT conditions (REE vs. ERE) (p = 0.238). The ESs demonstrated a moderate reduction in RPP for REE (ESs = -0.66) and small difference for ERE (ESs = -0.25) in post-tests. (Figure 3)

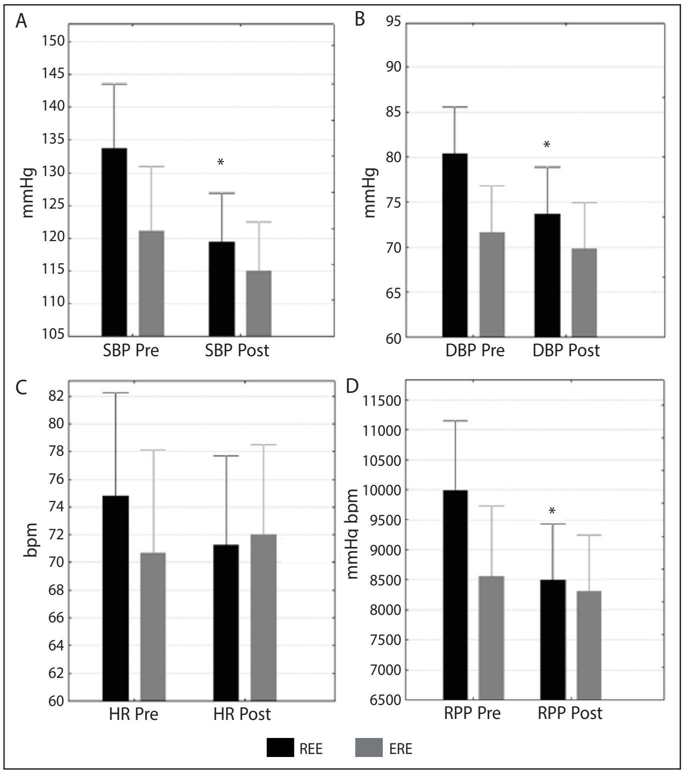

Figure 3. PRE and POST Cardiovascular outputs.

DISCUSSION

The key findings of this investigation regard to the strength gained from both groups when comparing the Pre and Post-test situation for all exercises independent of the CT order. For the cardiovascular outputs, the REE group triggered greater magnitudes of reductions (SBP, DBP, and RRP) highlighted by the ESs, although, without difference between groups for Pre and Post-test.

Regarding the neuromuscular adaptations and CT, our results align with Chtara et al.[12] that found no difference in muscle strength by altering the CT order. In addition, Collins and Snow[14] found that strength appears to be independent of whether endurance training occurs prior or post strength exercises. In accordance to the previous study, Gravelle and Blessing[13] found no difference on strength development for women performing CT without an influence of the exercise modality order. Several other experiments highlighted the occurrence of increased strength and functional capacity regardless of the execution exercise order.[21,22] Furthermore, de Souza et al.[23] demonstrated that despite the differences in the molecular adjustments between training regimens, CT promoted similar muscle strength and hypertrophy increments when compared with resistance exercise alone.

Endurance training and resistance exercise are recommended for adults with hypertension to lower blood pressure. The combined influence of these exercise modalities on resting blood pressure is unclear, even though it is known that CT is an effective antihypertensive therapy.[11] In a study conducted with normotensive college athletes, Davis et al.[8] concluded that both vigorous serial and integrated CT produced discernible cardiovascular adjustments, with the integrated method being more effective for blood pressure decrease. In another experiment, Kraemer et al.[9] investigated the comprehensive physiological alterations that take place during the combination of bench-step endurance and resistance exercise training in normotensive women. In the CT (bench-step endurance with resistance exercise) all cardiovascular responses were beneficial, including, DBP that demonstrated the same decrease in resting (6.7 mm Hg) as the endurance group (5.8 mm Hg). The data from non-athletes suggested that resistance, endurance, and CT exercises induce similar reductions in blood pressure. In contrast, Antunes et al.[10] observed the effects of a 20-week CT intervention program on gender-specific cardiovascular parameters in obese adolescents. No significant differences in SBP and DBP after 20-weeks of CT were found for obese boys and girls.

Regarding the type of exercise order, it has been shown that CT improved maximal and submaximal endurance performance in elderly men, independent of intra-session exercise order. However, it seems that when endurance exercise is performed before the strength regiment, this design elicited more individual responsiveness in terms of maximal endurance performance than the reverse order.[24] Recently, a line with those findings, Ramos et al.[25] that there is no preference for combined training order to improve VO_{2max} in hypertensive women.

It is well documented that regular physical exercise tends to have a favorable impact on blood pressure in the short and long-term[26] due to adjustments of central and local mechanisms, with a reduction in cardiac output and peripheral vascular resistance. The physiological mechanisms that could explain the reduction in blood pressure could be in part due to the reduction in vascular resistance caused by the release of dilating endothelial substances (e.g., nitric oxide and prostaglandins).[27] Furthermore, baroreflex compensation mechanisms that redefine the lower values obtained, thus resulting in a decreased cardiac output and sympathetic activation[28] could also contribute. The stimulus for the specific response seems to be caused by an increase in blood flow[29] in this case, triggered by the exercise.

Corroborating partially with the data of the present study, new epidemiologic data strongly recommends the inclusion of resistance exercise routines in physical activity regimens for reduced risk of several cardiovascular diseases and type 2 diabetes, independent of endurance training.[30] Besides, it seems that for an adult diagnosed with hypertension, resistance exercise may elicit blood pressure reductions and this decrease is comparable or even higher than those reportedly achieved with aerobic training.[31]

The present study investigated the cardiovascular adjustments in hypertensive women that performed a 12-week exercise regimen in distinct CT order. Our findings appear to be in partial agreement with the most recent results on cardiovascular benefits for different types of physical exercise. In fact, the CT order seems to affect the cardiovascular parameters. Specifically, REE group was more beneficial in SBP, DBP and RPP adaptations. Significant decreases were evident in blood pressure and RPP data when resistance exercise started exercises routines, which did not occur in ERE group. These findings support the idea that physical exercise regimens that contain parts in the endurance and resistance exercises should be initiated by the strength protocol. This seems to be one of the first studies focused on evaluating the chronic responses of blood pressure, HR, and RPP in hypertensive women with regards to a distinct CT order.

CONCLUSION

Regardless of CT order, the endurance and resistance exercise promoted significant strength gains in 12-week training for this population. However, in resistance exercise to endurance training order, the cardiovascular chronic outcomes (SBP, DBP and RPP) were significantly beneficial for controlling hypertension purposes. However, the authors recommend that future studies be performed in order to test distinct models of CT in distinct populations intending to further investigate those relations.

All authors declare no potential conflict of interest related to this article

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