Different order of combined exercises: acute effects on 24-hour blood pressure in young men

CDD. 20.ed. 796.022
796.071

http://dx.doi.org/10.1590/1807-55092016000400883

Rafaello Pinheiro MAZZOCCANTE*
Sérgio Rodrigues MOREIRA**
Ioranny Raquel Castro de SOUSA*
Rafael SOTERO*
Herbert Gustavo SIMÕES*
Guilherme Morais PUGA***
Carmen Silvia Grubert CAMPBELL*

*Universidade Católica de Brasília, Brasília, DF, Brasil.
**Colegiado de Educação Física, Universidade Federal do Vale de São Francisco, Vale de São Francisco, PE, Brasil.
***Instituto de Ciências Biomédicas, Universidade Federal de Uberlândia, Uberlândia, MG, Brasil.

Abstract

To verify 24-hour blood pressure (BP) responses in young adults after different orders of aerobic (AE) and resistance exercises (RE). Anaerobic threshold (AT) and strength (12 RM) were evaluated in ten healthy men (22.6 ± 3.7yrs; 70.3 ± 5.8 kg; 175.9 ± 5.8 cm). Four experimental sessions: Aerobic + Resistance (AR); Resistance + Aerobic (RA); Concurrent circuit (CC) and control day (CO) were randomly performed. All sessions had the same duration and intensity, AE: 15 min at 90% of AT; ER: 15 min at 90% of 12 RM with 12 reps (6 exercises). BP was measured before, during and 1 h (Microlife® BP3A1C) after performing exercises in the laboratory and 23 h during daily activities using ambulatory blood pressure measurement (Dyna-MAPA®). Systolic BP (SBP) in 24 h and awake periods, and Diastolic BP (DBP) in 24 h, sleep and awake periods, and Mean BP in awake period were lower in RA session compared with CO session with moderate to high effect size (d de Cohen = -0.46/-0.78). The DBP area under the curve in RA was lower than CO in awake (1004 ± 82 vs. 1065 ± 107; $p < 0.047$) and 24 h (1456 ± 103 vs. 1528 ± 132; $p < 0.026$) periods. The SBP delta were lower in RA at 0-1 h (-12.0 mmHg), 2-3h (-16.5 mmHg), 6-7 h (-19.4 mmHg) and 10-11 h (-13.0 mmHg) compared with CO; lower in AR at 4-5h (-19.2 mmHg) and 6-7 h (-20.2 mmHg) compared with CO; and lower in CC at 2-3h (-15.6 mmHg) and 6-7 h (-17.5 mmHg) compared with CO. The DBP was lower at 4-5 h (-14.0 mmHg) in RA compared with CO. After performing RA exercises, there were greater decreases in BP during 24 h in young adults.

KEY WORDS: Structure of session; Combined exercise; Blood pressure responses; Exercise prescription; Health.

Introduction

There is increasing incidence and prevalence of cardiovascular disease all over the world. Around 27.4% of all deaths in Brazil are due to cardiovascular disease[1]. In 2011, the treatment of systemic hypertension alone, cost the Institute of Health in Brazil over US$ 20 million[2]. There are many contributory factors to the development of hypertension, such as smoking, unhealthy diet and physical inactivity, however, these appear to be modifiable behaviors for treatment of this disease[3-5].

Epidemiological and clinical studies have highlighted the benefits of physical exercise (PE) for cardiovascular health[6-9]. One of these benefits is related to the reduction in blood pressure (BP) during recovery after a single bout of PE, in comparison with resting values, and this phenomenon is called post-exercise hypotension (PEH)[10-12]. PEH has been considered an important tool to aid the treatment of hypertension, in addition to being non-drug and cost effective strategies in hypertension prevention, reduction and control[13-15]. Some studies have shown PEH after performing only one session of PE (aerobic or resistance exercise) in elderly[16], diabetic[3-4, 17] hypertensive[18] and normotensive[19] individuals.

The reduction in PEH found after performing aerobic exercise (AE) appears to be greater, and longer lasting than it is after resistance exercise (RE)[20], however, further studies are necessary to evaluate the effects of concurrent exercise (CE), which allies the two types of exercise, on PEH. CE has become a very usual exercise prescription, but more information is required, with regard to the order of exercises and their effects on PEH.

Ambulatory blood pressure monitoring (ABPM) is an important tool in the prognosis of cardiovascular risk factors and investigation of BP responses, because it can monitor BP responses during 24 h of an individual's daily life (awake and sleeping). Most of the aforementioned studies have investigated the BP responses for 90-120 minutes after performing exercise[12, 14, 19-20], which leaves a gap in information over a longer period of acute cardiovascular response after performing exercise. Therefore, studies using ABPM may have important relevance to elucidate scientific questions concerning immediate and late acute responses after this exercise. Thus, the aim of this study was to assess the 24 h BP response in young adults after performing different orders of combined AE and RE.

Method

Experimental approach to the problem

In this study, the experimental design was performed in seven visit days, the first days the volunteers had their body composition measured, anaerobic threshold, maximum oxygen uptake (VO_{2max}) and familiarized and performing 12 repetition maximum test (12 RM). After first three days, was start random the experimental protocol in four days. The experimental protocol was combined exercise with different sessions: 1) aerobic + resistance session (AR); 2) resistance + aerobic session (RA); 3) concurrent circuit (CC); and 4) control session (CO). All sessions had monitoring BP for 24 hours after the exercise and control sessions. All volunteers were instructed not to perform exercise during the 24 hours that preceded the experimental sessions and were oriented to keep their regular feeding habits).

Participants

This study was approved by the local Human Research Ethics Committee of the Catholic University of Brasilia (Protocol n. 126/10). Ten healthy young men (22.6 ± 3.7 years, 70.3 ± 5.8 kg, 175.9 ± 5.8 cm and 6.8 ± 2.3% body fat), participated in this study after signing a term of free and informed consent. The volunteers were selected were Jiu-jitsu athletes, at competition level of the Brazilian Midwest and Pan American tournaments (TABLE 1).

Procedures

The exclusion criteria were as follows: were abnormality in the resting electrocardiogram; osteo-myo-articular injury; cardiometabolic disease and / or; resting systolic BP > 140 mmHg and / or diastolic BP > 90 mmHg). Each subject performed a total of seven trials, on separate days, at physiology and strength exercise laboratory facilities, as follows: 1st Visit - anthropometric measurements[21] and familiarization on resistance exercise equipment and with the 12 repetition maximum test (RMs); 2nd visit - aerobic fitness evaluation; 3rd visit - 12 RMs test, 4th, 5th, 6th and 7th visits - experimental sessions performing AE and RE in different orders in the same session. Volunteers were instructed to refrain from PE, and not to change their daily diet 24 h before the experimental sessions.

Aerobic fitness assessment

All volunteers performed a 1600 m-time trial on track and field of 400 m. Maximum oxygen uptake (VO_{2max}) and Anaerobic threshold (AT) intensities were estimated using the mean speed of this test according to the equations of Almeida et al.[22] and Sotero et al.[23].

Strength assessment (12 RMs)

Before the strength test (12 RMs) all volunteers performed familiarization exercises on each item of exercise equipment used in the study. The exercise 12 RMs test sequences were: Leg press, shoulder vertical, Leg extensor, lat pull down, leg curl and pull back. Each volunteer had up to four trial exercises separated by three to five minute intervals to achieve the maximum 12 RM on each item of exercise equipment.

Aerobic exercise (AE)

The AE were performed on a treadmill (Movement®, São Paulo, Brazil), at 90% of AT intensity for 15 minutes.

Resistance exercise (RE)

The RE was performed in a circuit, changing upper and lower limb exercises at 90% of 12 RMs intensity. The volunteers performed a circuit of six exercises three times (Righetto, Powertec, São Paulo, Brazil) in the same order as that of the previously mentioned 12 RMs test. Each repetition had two-second cycles of movement (eccentric and concentric), and the entire RE session lasted 15 minutes.

Experimental sessions

All volunteers performed four experimental sessions in random order with an interval of at least two days between sessions in a room with a controlled temperature between 20-24 ºC and at the same time of day (between 3:00 pm and 4:45 pm), as follows:

- Aerobic + Resistance session (AR): AE was performed before RE;
- Resistance + Aerobic session (RA): RE was performed before AE;
- Concurrent circuit exercise (CC): AE and RE were performed alternatively during the full session, beginning with AE. This session consisted of 5 "loops". Each AE lasted 3 minutes, and RE in the 1st and 3rd "loops" consisted of two series of two exercises; the 2nd loop consisted of 1 series of 4 exercises, and the 5th "loop" consisted of one series of two exercises. These exercise session consisted of the same volume as the other sessions, but with exercises performed in different orders;
- Control session (CO): This session had the same duration as the others, but instead of exercise, the participants remained at rest in a sitting position.

Blood pressure (BP) measurement

Systolic BP (SBP), diastolic BP (DBP) and mean arterial pressure (MAP) were measured before, during and after experimental sessions. Resting BP was measured in a sitting position, at 5, 10 and 15 minute intervals, and the real value was the average of these three resting measurements. During all sessions, BP was measured after the last exercise performed (AR or RE). After all sessions blood pressure was measured every 15 minutes for the next 60 minutes, resting in a sitting position. All BP measures were taken using a BP analyzer (Microlife® mod. BP3A1C).

After the above-mentioned 60 minutes, the participants were instructed to perform their personal hygiene in a time interval of 20 minutes, and prepare themselves to use the ambulatory BP monitor (Dyna-MAPA®), in accordance with the manufacturer's instructions. The ambulatory blood pressure measurements were taken during a period of 23 hours, one hour after the measurement taken in the laboratory facilities, totaling 24 hours of BP measurements taken. SBP, DBP and MAP were measured every 15 minutes during the awake period (15 hours) and every 30 minutes during the sleep period (9 hours). These measurements were considered valid when 90% of all measurements were recorded.

Heart rate (HR) and Rate of perceived exertion (RPE) measurements

During AE, the rate of perceived exertion (RPE) was measured using the 15 points Borg scale[24] and during RE, RPE was measured using the OMNI-RES scale[25-26]. The HR was measured during both AE and RE using an HR monitor (Polar, RS800CX, Finland).

Statistical analysis

Descriptive statistical analysis was used to estimate the mean ± standard deviation. Data normality was tested using the Shapiro-Wilk test. The Mauchly or Greenhouse-Geisser Estimate Epsilon test was also applied when necessary. The area under the curve was estimated using the trapezoidal method for blood over time analysis. ANOVA for repeated measures was used to compare within sessions and when necessary the Bonferroni test was applied as a Post-hoc test. The level of Significance was $p \leq 0.05$ and all analyses were performed using the SPSS v.20 software program.

Results

Participants' characteristic and aerobic fitness assessments are presented in TABLE 1.

The HR, RPE, running speed in AE and number of repetitions in RE, and BP during and immediately after performing exercise are presented in TABLE 2. The RPE was higher during AE in RA compared with AR and CC sessions ($p \leq 0.05$), on the other hand, during RE the RPE was lower in the RA session compared with the AR session ($p \leq 0.05$).

TABLE 2 also shows BP results immediately after performing exercise. SBP was higher after the first exercise performed in all sessions (AR, RA, CC) when compared with the CO session ($p \leq 0.05$). MAP was higher after the first exercise performed in sessions AR and RA when compared with CO ($p \leq 0.01$), and lower after the second exercise performed in the AR session compared with the MAP after the first exercise.

TABLE 1 - Anthropometric and aerobic fitness characteristics (n = 10).

	Mean ± SD
Age (years)	22.6 ± 3.8
Body mass (kg)	70.3 ± 5.9
Height (cm)	175.0 ± 5.8
BMI ($kg.m^{2(-1)}$)	22.6 ± 1.3
Body fat (%)	6.8 ± 2.4
VO_{2max} ($mL.kg^{-1}.min^{-1}$)	50.2 ± 4.3
Anaerobic threshold ($km.h^{-1}$)	12.3 ± 1.5

BMI: Body mass index; VO_{2max}: Maximal oxygen uptake.

TABLE 2 - Rate of perceived exertion (RPE), heart rate (HR), speed - $km.h^{-1}$, number of repetition, systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial pressure (MAP) during aerobic exercise (AE) and resistance exercise (RE) performed in different orders in experimental sessions (n = 10).

		AR	RA	CC	CO
AE	RPE (Borg)	11 ± 2**	14 ± 3	11 ± 2 **	--
	FC (bpm)	171 ± 1	179 ± 9	176 ± 9	--
	Speed ($km.h^{-1}$)	12 ± 1	11 ± 2	12 ± 1	--
RE	RPE (Omni)	7 ± 1	6 ± 1 *	6 ± 2	--
	Repetition	12 ± 1	12 ± 1	12 ± 1	--
SBP (mmHg)	M1	153 ± 21#	155 ± 13 #	146 ± 11 #	119 ± 7
	M2	128 ± 13	144 ± 26	138 ± 20	117 ± 8
DBP (mmHg)	M1	80 ± 13	84 ± 11	77 ± 17	71 ± 13
	M2	75 ± 10	75 ± 18	78 ± 14	67 ± 8
MAP (mmHg)	M1	105 ± 8 #	102 ± 20 #	100 ± 12	87 ± 9
	M2	93 ± 10 α	93 ± 24	98 ± 12	84 ± 7

M1: Immediately after the first exercise performed; M2: Immediately after the second exercise performed; AR: Aerobic and Resistance exercise session; RA: Resistance and aerobic exercise session; CC: Concurrent circuit session; CO: Control session; AE: Aerobic exercise; RE: Resistance exercise. *$p < 0.05$ as regards AR.; **$p < 0.01$ as regards RA; #$p < 0.05$ as regards CO session; $^{\alpha}p < 0.05$ as regards M1.

Although there was no reduction in SBP, DBP and MAP during entire 24 h period, sleep and awake periods, the results demonstrated reductions of greater magnitude in the RA session in comparison with the CO and other sessions, as occurred in the SBP values in the total period of 24 h and awake periods between session RA and CO, considered moderate to large effect sizes (Cohen's d), respectively (TABLE 3). DBP values were not different in the RA session compared with AR, CC and CO sessions in the total 24 h sleep and awake periods, with a moderate effect size (Cohen's d), with the same results in MAP during the awake period.

The AUC values of DBP in the RA session were lower compared with awake and total 24 h periods in CO session (TABLE 4).

TABLE 3 - Ambulatory blood pressure monitoring (ABPM) results during total 24 h awake and sleep periods after experimental sessions (n = 10).

		AR	RA	CC	CO
SBP (mmHg)	Resting	121 ± 4	121 ± 6	119 ± 6	117 ± 5
	24 h	111 ± 5	110 ± 3 #	111 ± 4	112 ± 5
	Awake	113 ± 7	111 ± 4 #	114 ± 4	116 ± 6
	Sleep	105 ± 5	106 ± 2	105 ± 5	106 ± 4
DBP (mmHg)	Resting	69 ± 8	69 ± 4	66 ± 3	66 ± 9
	24 h	63 ± 7	60 ± 3 †	63 ± 3	63 ± 5
	Awake	65 ± 7	62 ± 3 †	65 ± 3	65 ± 6
	Sleep	60 ± 8	56 ± 4 †	58 ± 4	59 ± 5
MAP (mmHg)	Resting	80 ± 9	81 ± 8	79 ± 10	79 ± 10
	24 h	83 ± 6	82 ± 3	84 ± 4	84 ± 6
	Awake	85 ± 7	83 ± 4 #	86 ± 4	87 ± 7
	Sleep	79 ± 7	79 ± 3	79 ± 6	78 ± 5

AR: Aerobic and Resistance exercises session; RA: Resistance and aerobic exercise session; CC: Concurrent circuit session; CO: Control session; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; MAP: Mean arterial pressure. #difference in magnitude of effect in comparison with same period in control (Cohen's d = -0.49 to 0.50); †difference in magnitude of effect in comparison with same periods in CO, AR and CC sessions (Cohen's d = -0.46 to -0.78).

TABLE 4 - Ambulatory blood pressure measurement (ABPM) Area under the curve during total 24h awake and sleep periods after experimental sessions (n = 10).

		24 h (mmHg * 24 h)	Awake (mmHg * 15 h)	Sleep (mmHg * 9 h)
SBP	AR	2743 ± 138	1874 ± 123	869 ± 44
	RA	2721 ± 71	1846 ± 64	876 ± 21
	CC	2760 ± 98	1879 ± 76	880 ± 40
	CO	2787 ± 137	1913 ± 112	874 ± 32
DBP	AR	1505 ± 169	1033 ± 122	472 ± 63
	RA	1456 ± 103 *	1004 ± 82 *	452 ± 33
	CC	1506 ± 103	1045 ± 86	461 ± 32
	CO	1528 ± 132	1065 ± 107	463 ± 38
MAP	AR	1985 ± 153	1356 ± 125	629 ± 55
	RA	1960 ± 85	1332 ± 73	628 ± 20
	CC	1998 ± 97	1381 ± 78	617 ± 33
	CO	1985 ± 136	1357 ± 104	628 ± 47

SBP: Systolic blood pressure; DBP: Diastolic blood pressure; MAP: Mean arterial pressure; AR: Aerobic and Resistance exercises session; RA: Resistance and aerobic exercise session; CC: Concurrent circuit session; CO: Control session; *p < 0.05 at same time in comparison with CO.

FIGURES 1 and 2 show BP delta during 24 h of ABPM in all experimental sessions. The SBP at 4 to 5 h ($p < 0.02$) and 6 to 7 h ($p < 0.001$) were lower in the AR session than CO session, and also at 0 to 1 h ($p < 0.04$), 2 to 3 h ($p < 0.004$), 6 to 7 h ($p < 0.01$) and 10 to 11 h ($p < 0.03$) in the RA session compared with CO session.

AR: Aerobic and resistance exercises session;
RA: Resistance and aerobic exercise session;
CC: Concurrent circuit session;
CO: Control session;
*p < 0.05 for AR vs. CO;
**p < 0.01 for AR vs. CO;
#p < 0.05 for RA vs. CO;
£ p < 0.01 for RA vs. CO;
¥p < 0.01 for CC vs. CO.

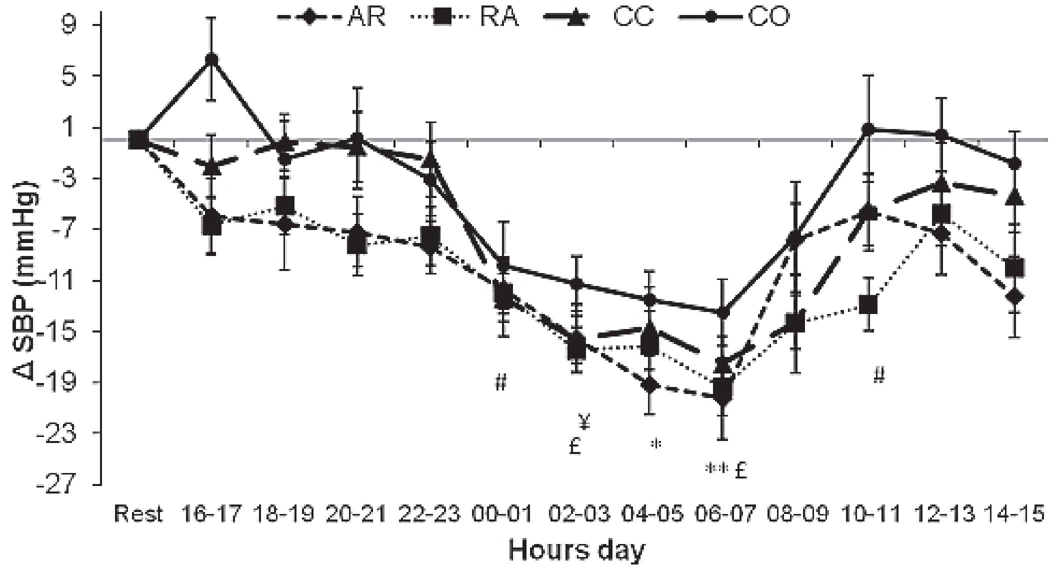

FIGURE 1 - Systolic blood pressure delta (Δ SBP) during resting (REP) and 24 hours of ambulatory blood pressure monitoring (ABPM) in all experimental sessions.

AR: Aerobic and resistance exercises session;
RA: Resistance and aerobic exercise session;
CC: Concurrent circuit session;
CO: Control session;
**p < 0,01 for RA vs. CO.

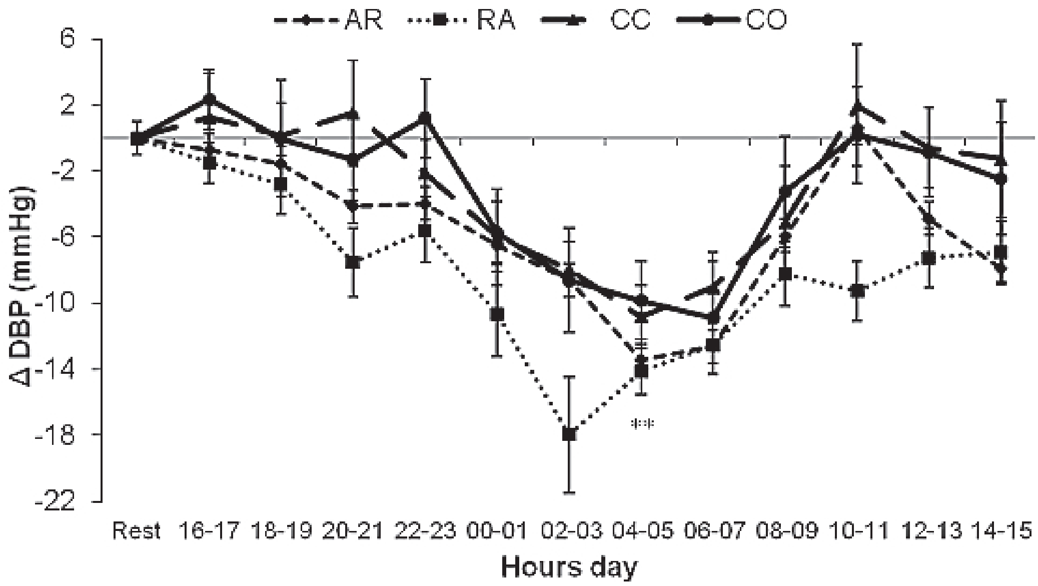

FIGURE 2 - Diastolic blood pressure delta (Δ DBP) during resting (REP) and 24 hours of ambulatory blood pressure monitoring (ABPM) in all experimental sessions.

Discussion

The main findings of this study were that combined exercise performed in different orders, in the same exercise session, promotes different acute responses in a period of 24 h of BP responses in young adults. We found that RE performed before AE (RA session), decreased both SBP and DBP in more of the time points during 24 h than the session without performing exercise (FIGURES 1 and 2). Moreover, during the total 24 h awake and sleep periods, DBP had larger differences in effect size in the RA session, compared with the AR, CC and CO sessions (TABLE 3). These results were confirmed by AUC of DBP during the total 24 h awake and sleep periods, which were lower only in the RA session compared with the CO session (TABLE 4).

Lovato et al.[26] compared AE performed at 60% of VO_{2peak} and RE at 60% of 1 RM (15 repetitions) in different orders of performance in normotensive young males, and showed different results. Their results showed lower SBP until 50 min and lower DBP and MAP until 40 min when AE was performed before RE. Similar results were found by Ruiz et al.[27], who showed lower SBP for 60 min after concurrent exercise performed (AE performed first) in normotensive volunteers. In this study, there was no reduction in DBP, which corroborate our findings. These different results mentioned above may be due to lower intensity and possibly a higher volume of exercise performed in these studies in comparison with the exercises performed in our study.

Kesse et al.[20] investigated the effects of combined exercise performed (RE performed first) at different exercise intensities of AE (50%, 65% and 80% of VO_{2peak}) in 21 young adults. In this study the authors showed that SBP decreased in all time points after performing exercise in all experimental sessions, and these decreases were dependent on exercise intensity. These results reinforce the strategy of performing AE at the end of the training session, for better reductions in BP, similar to our results.

Our study did not show PEH, but SBP and DBP AUCs were lower in the RA session compared with CO session. Keese et al.[28] studied the same concurrent exercise model as used in our study, in young participants, and showed a reduction in SBP up to 2 h; and in DBP up to 50 min after performing exercise. Our study also presents BP response during the course of 24 h after performing exercise, which was not shown in the aforementioned studies.

Although the RA session showed more time points with BP responses below those of the other sessions, all the experimental sessions of combined exercises, promoted important clinical cardiovascular protection. According to some authors, a reduction of only 2 mmHg in SBP and DBP for long periods reduces the risk of developing cardiovascular diseases and events[5], such as 6% less incidence of strokes, and 4% fewer coronary artery diseases and 17% less development of hypertension in the general population[5].

Some AE models have shown reductions in BP[20], but Shaw et al.[29] found that chronic concurrent exercise (AE + RE) promoted similar effects on reducing the development of coronary diseases and lowering BP, compared with performing aerobic exercise alone. Teixeira et al.[30] showed that concurrent exercise, (with AE performed first) led to similar decreases in BP in comparison with aerobic exercise performed alone, and both exercises promoted lower BP than RE performed alone. It is important to note that concurrent exercise can improve both the cardiovascular and neuromuscular system, which is better than aerobic exercise performed alone[20]. Our results showed important reductions in BP after RA exercise sessions, therefore, when these data are taken together, it is possible that these combined exercises performed in long periods can benefit both the cardiovascular and neuromuscular systems in young adults[20, 27-28].

The results from our study do not show possible mechanisms to explain the reduction in BP after performing exercise, but central and peripheral mechanism are presented in these responses[31]. Further studies are needed to investigate BP responses and reduction after performing combined exercises similar to those used in our study.

This study verified BP responses in young fighter (Jiu-Jitsu) athletes, who may have obtained better results and benefits, which restricts its application in patients with cardiovascular diseases. On the other hand, the participants in our study had similar characteristics (TABLE 1) and daily life activities, such as exercise, rest and sleep times, which minimize inter-individual variation.

We concluded that the order of performing combined exercises, in the same exercise training session, promoted different BP responses, in young adults, in the period of 24 h after performing them. Resistance exercise performed first, and then aerobic exercise, led to a greater reduction in BP for 24h after performing them, than when aerobic exercise was performed first.

Practical applications

The combined exercise is a usual practice in training centers. However, the influence of this model of training on blood pressure have been less investigated. The results presented here can be useful for professionals involved in exercise prescription for cardiovascular health. Resistance exercise performed before aerobic exercise in the same session of 30 minutes, decreased both SBP and DBP in more of the time points during 24 h than the session without performing exercise.

Apparently healthy adults aiming blood pressure control and cardiovascular protection by maintenance of values within the normal can benefit from session training involving 15 minutes of resistance exercise and 15 minutes of aerobic exercise. The training sessions may be composed by six resistance exercises, performed in a circuit model, changing upper and lower limb exercises at 90% of 12 RMs intensity (each repetition had two-second cycles of movement - eccentric and concentric). The circuit of resistance exercise may be performed in 3 laps. The aerobic exercise can be conducted using the linear model of running in intensity of 90% of anaerobic threshold. In addition, a previous medical screening including orthopedic, cardiovascular, and metabolic evaluation is recommended.

Resumo

Diferentes ordens do exercício combinado: efeitos agudos de 24 horas sobre a pressão arterial de atletas

Verificar as respostas de 24 horas da pressão arterial (PA) em jovens adultos após diferentes ordens de execução do exercício aeróbio (EA) e resistido (ER). Participarão do estudo dez homens saudáveis (22,6 ± 70,3; 3.7 anos ± 5,8 kg; 175,9 ± 5,8 centímetros). O estudo consistiu em quatro sessões experimentais realizadas de forma aleatórias: EA + ER (AR); ER + EA (RA); Circuito Concorrente (CC) e controle (CO). Todas as sessões tiveram a mesma duração e intensidade, EA: 15 min a 90% do limar de lactato mínimo indireto; ER: 15min a 90% de 12 RM com 12 repetições (seis exercícios). A PA foi medida antes, durante e 1 h (Microlife® BP3A1C) após a realização de exercícios em laboratório e 23 h durante as atividades diárias, utilizando a medição da pressão arterial ambulatorial (Dyna-MAPA®). A pressão arterial sistólica (PAS) no período de 24 horas e de vigília, e a diastólica (PAD), no período de 24 horas, o sono e de vigília, e a média da PA no período de vigília foram menores na sessão RA em comparação com a sessão CO apresentando um tamanho do efeito de moderado a alto (d de Cohen = -0,46 / -0,78). A área sob a curva da PAD na sessão AR foi menor do que na sessão CO no período de vigília (1004 ± 82 vs. 1065 ± 107; p < 0,047) e 24 h (1456 ± 103 vs 1528 ± 132; p < 0,026) períodos. A sessão RA apresentou maiores pontos de redução da PA durante 24 horas em relação ao outros protocolos.

Palavras-chave: Estruturação de treino; Exercício combinado; Respostas de pressão arterial; Prescrição de exercício; Saúde.

References

1. Sociedade Brasileira de Cardiologia. V Diretrizes Brasileiras de Hipertensão Arterial. Arq Bras Cardiol 2007;89.
2. Brasil. Ministério da Saúde. Sistema de Informações Hospitalares do SUS (SIH/SUS). [cited 2012 Apr 10]. Available from: http://tabnet.datasus.gov.br/cgi/deftohtm.exe?sih/cnv/niuf.def.
3. Morais PK, Campbell, CSG, Sales MM, et al. Acute resistance exercise is more effective than aerobic exercise for 24 h blood pressure control in type 2 diabetics. Diabetes Metab. 2011;37:112-7.
4. Motta D, Lima L, Arsa G, et al. Influence of type 2 diabetes on kallikrein activity after physical exercise and its relationship with post-exercise hypotension. Diabetes Metab. 2010;36:363-8.

5. Pescatello LS, Franklin BA, Fagard R, et al. Exercise and hypertension. Med Sci Sports Exerc. 2004;3:533-53.
6. Queiroz ACC, Kanegusuku H, Forjaz CLM. Efeitos do treinamento resistido sobre a Pressão Arterial de idosos. Arq Bras Cardiol. 2010;95:135-40.
7. Medina FL, Lobo FS, Souza DR, et al. Atividade física: impacto sobre a pressão arterial. Rev Bras Hipertens. 2010;2:103-6.
8. Siqueira FPC, Veiga EV. Hipertensão arterial e fatores de risco. Enferm Bras. 2004;3:101-6.
9. Shaw I, Shaw BS, Brown GA, Cilliers JF. Concurrent resistance and aerobic training as protection against heart disease. Cardiovasc J Afr. 2010;21:196-9.
10. Forjaz CLM, Rezk CC, Melo CMM, et al. Exercício resistido para o paciente hipertenso: indicação ou contra-indicação. Rev Bras Hipertens. 2003;10:119-24.
11. MacDonald JR. Potential causes, mechanisms, and implications of post exercise hypotension. J Hum Hypertens. 2002;16:225-36.
12. Lizardo JH, Simões HG. Efeito de diferentes sessões de exercícios resistidos sobre a hipotensão pós-exercício. Rev Bras Fisioter. 2005;3:249-55.
13. Siqueira FPC, Veiga EV. Hipertensão arterial e fatores de risco. Enferm Bras. 2004;3:101-6.
14. Polito MD, Farinatti PTV. Comportamento da pressão arterial após exercícios contra-resistência: uma revisão sistemática sobre variáveis determinantes e possíveis mecanismos. Rev Bras Med Esporte. 2006;12:386-92.
15. Farinatti PTV, Oliveira RB, Pinto VLM, Monteiro WD, Francischetti E. Programa domiciliar de exercícios: efeitos de curto prazo sobre a aptidão física e pressão arterial de indivíduos hipertensos. Arq Bras Cardiol. 2005;84:473-9.
16. Santana HAP, Moreira SR, Silva VC, et al. The higher exercise intensity and the presence of allele i of ace gene elicit a higher post-exercise blood pressure reduction and nitric oxide release in elderly women: an experimental study. BMC Cardiovasc Disord. 2011;11:71-8.
17. Sales MM, Russo PS, Moreira SR, et al. Resistance exercise elicits acute blood pressure reduction in type-2 diabetics. J Exerc Physiol. 2012;15:98-109.
18. Moraes M, Bacurau R, Ramalho J, et al. Increase in kinins on post-exercise hypotension in normotensive and hypertensive volunteers. Biol Chem. 2007;40:388:533-40.
19. Rezk CC, Marrache RCB, Tinucci T, Mion Junior D, Forjaz CLM. Post-resistance exercise hypotension, hemodynamics, and heart rate variability: inxuence of exercise intensity. Eur J Appl Physiol. 2006;98:105-12.
20. Keese F, Farinatti P, Pescatello L, Monteiro W. A comparison of the immediate effects of Resistance, aerobic, and concurrent exercise on post-exercise hypotension. J Strength Cond Res. 2011;5:1429-36.
21. Jackson AS, Pollock ML. Generalized equations for predicting body density of men. Br J Nutr. 1978;3:497-504.
22. Almeida JA, Pardono E, Sotero RC, et al. Validade de Equação de predição em estimar o VO2max de brasileiros jovens a partir do desempenho em corrida de 1600m. Rev Bras Med Esporte. 2010;16:57-60.
23. Sotero RC, Pardono E, Campbell CSG, Simões HG. Indirect assessment of lactate minimum and maximal blood lactate steady state intensity for physically active individuals. J Strength Cond Res. 2009;23:847-53.
24. Rodrigues BM, Sandy DD, Mazini Filho ML, et al. Sessão de treinamento resistido para membro superior com dois diferentes tempos de intervalo: efeitos na percepção subjetiva de esforço. Braz J Biomotricity. 2010;4:131-9.
25. Lagally KM, Robertson RJ. Construct validity of the Omni resistance exercise scale. J Strength Cond Res. 2006;20: 252-6.
26. Lovato NS, Anunciação PG, Polito MD. Pressão arterial e variabilidade de frequência cardíaca após o exercício aeróbio e com pesos realizados na mesma sessão. Rev Bras Med Esporte. 2012;18:22-5.
27. Ruiz RJ, Simão R, Saccomani MG, et al. Isolated and combined effects of aerobic and strength exercise on post-exercise blood pressure and cardiac vagal reactivation in normotensive men. J Strength Cond Res. 2011;25:640-5.
28. Keese F, Farinatti P, Pescatello L, et al. Aerobic exercise intensity influences hypotension following concurrent exercise sessions. Int J Sports Med. 2012;2:148-53.
29. Shaw I, Shaw BS, Brown GA, Cilliers JF. Concurrent resistance and aerobic training as protection against heart disease. Cardiovasc J Afr. 2010;21:196-9.
30. Tsioufis C, Kyvelou S, Tsiachris D, et al. Relation between physical activity and blood pressure levels in young Greek adolescents: the Leontio Lyceum Study. Eur J Public Health. 2010;21:63-8.
31. Whelton PK, He J, Appel LJ, et al. Primary prevention of hypertension: clinical and public health advisory from The National High Blood Pressure Education Program. JAMA. 2002;15:1882-8.

Acknowledgments

The authors thank the Coordination for Improvement of Higher Education Personnel (CAPES) and the National Council for Scientific Development (CNPq) for granting scholarships to undergraduate (CNPq) and master (CAPES) level students.

ENDEREÇO
Rafaello Mazzoccante
Educação Física
Universidade Católica de Brasília
EPTC - QS07 - Bloco G - sala 001 - Águas Claras
87020-900 - Brasília - DF - BRASIL
e-mail: rafa_mazzocante@hotmail.com

Submitted: 12/23/2014
1a Review: 03/06/2015
1a Review: 07/156/2015
Accepted: 09/29/2015