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Address:-Ashok Yakkaldevi 258/34, Raviwar Peth, Solapur - 413 005 Maharashtra, India
Cell : 9595 359 435, Ph No: 02172372010 Email: ayisrj@yahoo.in Website: www.oldror.lbp.world

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REVIEW OF RESEARCH

ACUTE AND CHRONIC EFFECTS OF DIFFERENT EXERCISE TRAINING PROGRAMS IN BLOOD PRESSURE, LIPID PROFILE AND PHYSICAL FITNESS IN HYPERTENSIVE WOMEN

Régis Tribuzy de Oliveira[1,4] , Tiago Figueiredo[2,3] , Ewertton de Souza Bezerra[4] , Murillo Moraes[4]
De Angelys de Ceselles Seixas da Silva[2] , Francisco José Félix Saavedra[1] and Roberto Simão[2]

[1]Trás-os-Montes e Alto Douro University. Research Centre for Sport Health and Human Development. Vila Real, PORTUGAL.

[2]Rio de Janeiro Federal University. School of Physical Education and Sports. Rio de Janeiro, RJ 22941-590 - BRAZIL.

[3]Estácio de Sá University. Physical Education Graduation Program. Macaé, RJ - BRAZIL.

[4]Federal University of Amazonas. Faculty of Physical Education and Physiotherapy. Human Performance Laboratory. Manaus, AM – BRAZIL

ABSTRACT

BACKGROUND: the purpose of this study was to investigate the effects of different physical training types during 12 weeks on blood pressure, lipid profile, muscle strength, and physical fitness in hypertensive women. METHODS: Twenty-nine women (age: 53.27±10.7 years; weight: 70.41±10.3 kg; height: 152±6.1cm; systolic blood pressure >140mmHg; diastolic blood pressure <90 mmHg) were randomly assigned in four groups: Control group (n=8); aerobic training group (n=5); strength training group (n=8); concurrent training group (n=8) and perform 12 weeks of specific exercise type. RESULTS: intragroup results - Aerobic training group reduce systolic blood pressure (p<0.05); Strength training group reduce diastolic and mean blood pressure (p<0.05); Concurrent training group reduce systolic blood pressure (p<0.05). A significant increase in all three experimental groups in High Density Lipoprotein (p<0.05). No significant differences were found between the experimental groups (pre-post test). However, when comparing control group to the experimental groups, for blood pressure, strength on bench press and leg extension exercise, significant increases were found in training groups. Intragroup analysis for muscle strength: in two groups of strength and concurrent, there was significant increase in muscle strength in the bench press and leg extension (p<0.05). There were no significant results for VO2max, flexibility and body composition in all groups. CONCLUSIONS: in hypertensive women: the three experimental groups, can reduce acute or chronic blood pressure; the high-density lipoprotein is able to have a positive response to physical exercise, increase found in the three experimental groups; inactivity help boost the low-density lipoprotein, for the control group was the only one that increased significantly this bad cholesterol and strength and concurrent exercises are able to increase the strength of muscle upper and lower limbs.

KEYWORDS: *Hypertension - Post-exercise hypotension – Resistance – Strength.*

INTRODUCTION

High blood pressure (HBP) affects more than 25% of the world population and it is a risk factor to coronary arterial disease, myocardial infarction, stroke and renal failure, and associated with factors such as physical inactivity, genetics, age, overweight, obesity, glucose intolerance, insulin resistance, and low vascular reactivity (WHO, 2012). Exercise training is effective to control HBP (ACSM, 2004). It may cause acute and chronic post-exercise hypotension (PEH) in systolic blood pressure (SBP), diastolic blood pressure (DBP), and/or in the mean arterial pressure (MAP) (Junges et al., 2011), reducing cardiovascular morbidity (Medina, et al., 2011; Figueiredo et al., 2015).

Physical activity is an important non-pharmacological intervention for BP disorders. Aerobic training (AT) and strength training (ST) compose a well-rounded physical exercise program, promoting reductions in BP of normotensive and hypertensive individuals (ACSM, 2010; Mendes et al., 2011). Studies showed significant reductions in BP with different protocols of AT, such as walking, jogging and long distance running performed with different volumes and intensities (Fagard and Cornelissen, 2007; Pontes et al., 2008).

ST also, can treat cardiovascular disorders, promotes acute and chronic post-exercise reductions in rest BP (Cornelissen & Fagard, 2005; Williams et al., 2007), and reduction of cardiac output and in peripheral vascular resistance (Resk et al., 2006). Studies have examined PEH following ST sessions performed in different formats such as a circuit approach or a more traditional with consecutive sets performed for each exercise (Simão et al., 2005); different number of sets (Figueiredo et al., 2015), with different load intensities (Figueiredo et al., 2015); different rest intervals between sets and exercise orders (Fagherazzi & Bortolon, 2008; Goodwin et al., 2009; Figueiredo et al., 2013).

Besides AT and ST, concurrent training (CT) – combination of aerobic and strength exercises in the same session – is considered an effective alternative when controlling HBP and may cause acute or chronic post-exercise hypotension (Shaw, 2010). Thus, there is little information about the effects of different types of training on individuals with HBP. In this way, the purpose of this study was to investigate the effects of different training regimens on BP, lipid profile and physical fitness in hypertensive women. The hypothesis is that CT may cause greater hypotension, when compared to AT and ST performed isolated.

MATERIALS AND METHODS

Experimental approach to the problem

Subjects performed three exercise sessions per week, during 12 weeks. The dependent variables were collected in four days (baseline- and post-sessions). Day one: body mass, was measured with an analogical scale (Toledo, Brazil) and height was measured using a stadiometer (Toledo, Brazil). Two: after twenty four hours of rest, the second test day, flexibility and cardiorespiratory tests were applied. Three: lipid profile was assessed. Four: test of 10RM was applied for the bench press and leg extension, and measured blood pressure. All tests procedures were repeated after 6 and 12 weeks.

Subjects

Twenty-nine hypertensive women participated in this study. Were randomly assigned into four groups: control group (CG), aerobic training group (ATG), strength training group (STG) and concurrent training group (CTG), as shown in Table 01. Characteristics: a sedentary lifestyle for more than six months, diagnosed hypertension, no joint injury and be 40-70 years old. Prior to data collection, subjects were required to sign a consent form in accordance with human subject regulations. Subjects were instructed not to consume caffeine or alcohol, and maintain their routine activities and eating habits during the study period.

Table 01 - Mean values and standard deviation of experimental groups

Variables	CG (n=8)	ATG (n=5)	STG (n=8)	CTG (n=8)
Age (years)	43.25±10.11	61.8±9.12	56.65±7.25	54.63±8.81
Body Mass (Kg)	75.63±11.48	70.58±10.74	69.31±7.64	68.78±16.40
Height (cm)	1.54±0.04	1.51±0.07	1.52±0.04	1.53±0.07
BMI (Kg/m2)	24.48±3.05	30.77±2.39	29.80±3.16	29.41±5.37

CG: Control group; ATG: Aerobic training group;
STG: Strength training group; CTG: Concurrent training group.

PROCEDURES

Arterial BP assessment

Blood pressure (SBP, DBP and MAP) was measured using an automatic oscillometric device (Contec PM50 NIBP/Spo2, Contecmed, Qinhuangdao, China). All BP measurements were performed on the left arm (AHA, 2006). BP assessment took place in a quiet room with temperature control 220C. Subjects took place a ten-minute rest sitting on a chair for the first BP measurement; a second BP measurement was made five minutes after the first assessment. The mean of the two BP assessments was considered the baseline value. After the exercise protocol, BP acute was assessed during 60 minutes, with 10 minutes interval between assessments. The chronic effect of the intervention on BP was measured 72 hours after the last day of training (i.e. 72 hours after the 12-week exercise program).

Ten repetition maximum test (10RM)

The 10RM test was applied according to the American College Sports Medicine protocol (ACSM, 2009). 10RM test began with a warm-up at 50% of predicted 10RM load. Then, the predicted 10RM load was increased for the first attempt. Subjects were given a five-minute rest after each subsequent attempt; the test was over when there was mechanical failure or the subject refused to continue; the highest load lifted successfully was recorded as the 10RM value. 10RM test was repeated 72 hours later to establish reliability.

The following strategies were applied in order to avoid error during 10RM tests: a) standardized instructions concerning the test procedure were given to subjects before the test; b) subjects received standardized instructions on exercise technique; c) subjects were given verbal encouragement during the test procedure; d) the mass of all weights and bars used in the study were measured using a precision scale. Subjects were given three attempts with a rest interval of five minutes between 10RM attempts and a ten-minute interval between exercises to assess 10RM load (Simão et al., 2012).

Sit-and-Reach Test

Flexibility was measured before and after the 12 weeks of training using the Sit-and-Reach test protocol (Wells & Dillon, 1952). The flexibility measurement was taken 48 hours after the last 10RM test. Three trials were performed with a 10 seconds rest interval between attempts, and the best result was used for statistical analysis. All flexibility test was conducted at the same time of the day.

Cardiorespiratory Test

All subjects underwent a progressive exercise test for peak oxygen uptake (VO2peak) with an ergospirometry mechanism. A cycloergometer (Inbramed®, Brazil) and a portable gas analyzer K4 b2 (Cosmed, Rome, Italy) were used for the cardiorespiratory test. The protocol consisted of a five-minute warm-up with a standard load of 25W. The assessment of expired gases occurred every 10 seconds, determining VO2max and VO2peak. 25W load was increased in intervals of two minutes until voluntary exhaustion. The test was terminated by voluntary exhaustion or physical incapacity to keep cycling at a predetermined cadence (Issekutz et al., 2008).

Biochemical measurements

Lipid profile (LP) was assessed 72h before and after the 12 weeks of training. The blood collection occurred after 12h of fasting, and its analysis was made using the enzymatic colorimetric method of triglycerides (TG), total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL). Laboratory tests were made according to the National Glycohemoglobin Standardization Program (Netto, 2009).

Training sessions

Three training sessions per week were performed with intervals of 48h between sessions. CG did not perform any physical activity during the study period. The training program was conducted in four phases:

Phases 1 and 2 with 12 sessions each; phases 3 and 4 were composed by six sessions each. ATG walked between 30-60 minutes, with 55-70% of maximum heart rate and perceived exertion (RPE) between 9 and 13 rate of perceived exertion (Borg, 1982). STG performed 2-3 sets of each exercise, with 60-75% of 10RM load with three-minute rest between sets. The exercises for STG were: bench press, leg extension, shoulder press, lat pull down, biceps curl, abdominal crunch and plantar flexion – all performed using machines (Rotech, Brazil). CTG performed 20-30 minutes, with 55-70% of maximum heart rate and perceived exertion (RPE) between 9 and 13 rate of perceived exertion (Borg, 1982) and after, 2-3 sets of each force exercise, with 60-75% of 10RM load with three-minute rest between sets.

Statistical analysis

Data for all variables were analyzed using the Kolmogorov-Smirnov test and homogeneity of variances using the Levene test. Measurements of central tendency (mean) and dispersion (standard deviation) were applied to describe variables. The training effectiveness was analyzed by using two-way ANOVA [3 interventions (AT, CT and ST) x 5 dependent variables x 2 inputs (pre-and post-, intra-and inter-group)]. Bonferroni post-hoc test was applied to indicate the method that caused changes in the dependent variable. Alpha level was set at 0.05 for all analyzes.

All data was analyzed using SPSS 17.0 statistical package for Windows (SPSS Inc., Chicago, IL, USA). The exercise effect was analyzed using effect size (Rhea, 2004), that in the intragroup condition was used the reasoning: effect size = (mean POST - average PRE) / standard deviation PRE; in intergroup the reasoning was: effect size = (mean experimental - mean control) / standard deviation control. The scale of effect magnitude in strength training research and exercise for sedentary individuals was: Trivial (<0.50), Small (0.50 to 1.25), Moderate (1.25 to 1.9) and Large (>2.0).

RESULTS

Blood pressure and lipid profile

All variables demonstrated a normal distribution ($p<0.05$). The acute PEH effect was significant ($p<0.05$) for: a) SBP in ATG (after 10min) and STG (after 20 and 40min); b) DBP in CTG (after 10min, 20min) and STG (after 20, 30 and 60min); c) MAP in ATG (after 10min) and STG (after 20 and 40min). These results are presented in Table 02.

Table 02 – Acute Blood Pressure Results (Mean ± SD)

BLOD PRESSURE	GROUP	BASELINE	POST	10min	20min	30min	40min	50min	60min
SBP	ATG	122	122.4	* 115.2	118	118	122.4	117.2	118
		4.47	4.34	6.26	2.45	3.16	4.34	3.35	4.00
	STG	129.00	128.75	125.50	* 118.75	123.00	* 120.63	121.00	118.00
		7.15	14.34	12.22	11.26	14.06	10.88	12.24	13.61
	CTG	119.50	120.50	116.50	112.00	110.25	111.25	114.38	115.75
		13.72	16.31	20.02	14.97	12.35	15.38	13.44	15.25
DBP	ATG	75.6	75.2	75.6	79.2	74.0	79.6	73.2	72.8
		8.41	5.02	5.18	1.10	4.69	2.61	6.26	6.57
	STG	85.75	86.88	79.50	* 80.88	* 80.00	80.13	79.88	* 78.50
		7.87	9.91	9.89	7.36	7.71	7.79	7.30	6.91
	CTG	77.00	76.25	* 72.63	* 73.25	74.88	76.25	74.25	75.00
		8.68	9.16	8.50	8.00	5.22	6.09	8.03	7.71
MAP	ATG	* 121.67	122.07	114.87	117.67	117.67	122.07	116.87	117.67
		4.47	4.34	6.26	2.45	3.16	4.34	3.35	4.00
	STG	128.67	128.42	125.17	* 118.42	122.67	* 120.30	120.67	117.67
		7.15	14.34	12.22	11.26	14.06	10.88	12.24	13.61
	CTG	119.17	120.17	116.17	111.67	109.92	110.92	114.05	115.42
		13.72	16.31	20.02	14.97	12.35	15.38	13.44	15.25

ATG: Aerobic training group **STG**: Strength training group **CTG**: Concurrent training group

SBP: Systolic blood pressure **DBP**: Diastolic blood pressure **MAP**: Mean arterial pressure *: p<0,05 Baseline

The chronic hypotension effect (intragroup) was significant: Aerobic training group reduce systolic blood pressure ($p<0.05$); Strength training group reduce diastolic and mean blood pressure ($p<0.05$); Concurrent training group reduce systolic blood pressure ($p<0.05$). These data are presented in Table 03.

Table 03 - Chronic effect blood pressure and lipid profile

MEASURES	TRAINING GROUPS							
	CG		ATG		STG		CTG	
	BASELINE	POST	BASELINE	POST	BASELINE	POST	BASELINE	POST
SBP	129.12	127.5	122	*112.8	129	119.5	119.5	*110.5
	4.7	4.65	4.47	8.31	7.15	11.74	13.72	14.2
DBP	87.5	85.12	75.6	72	85.75	*72.37	77	72.37
	3.2	3.18	8.41	8.36	7.86	12.35	8.68	10.28
MAP	101.37	99.25	91.06	85.59	100.16	*88.08	91.16	89.12
	3.6	3.37	7.04	7.89	6.59	11.32	9.39	10.43
TG	105.25	135.87	163.8	246.2	153.87	179.87	143	171.87
	25.39	44.13	121.52	180.64	102.86	97.32	99.66	123.01
TC	178.25	197.87	234.8	235.8	239.75	242.75	203.37	232
	43.84	31.37	26.28	19.05	42.82	42.49	57.46	35.7
HDL	57.1	56.35	52.8	*64.64	56.12	*63.92	50	*64.81
	7.78	7.12	15.64	4.22	13.52	3.88	16.37	3.38
LDL	138.7	*146.78	148.64	128.54	152.87	142.88	132.27	138.37
	26.3	23.74	27.31	13.83	39.3	39.2	36.33	40.28
VLDL	21.17	23.92	34.16	36.94	30.75	34.02	28.97	33.9
	6.49	7.24	23.87	28.7	20.58	19.48	19.77	24.55

CG: Control Group **ATG**: Aerobic Training Group **STG**: Strength Training Group **CTG**: Concurrent Training Group **TG**: Triglycerides

TC: Total Cholester **HDL**: High Density Lipoprotein **LDL**: Low Density Lipoprotein **VLDL**: Very Low Density Lipoprotein *: p<0,05 Baseline

Muscle strength

The relationship between test and retest for measuring strength (10RM) showed excellent intraclass correlation between the two days of testing (bench press, r=0.90 and leg extension, r=0.92). Workloads were determined by the highest result. Bench press and leg extension exercises showed significant intergroup changes for STG (p=0.05) and CTG (p=0.01). In intergroup comparison, bench press strength increased significantly (p=0.001) for CTG and STG compared to CG, with small and large magnitudes, respectively. Leg extension showed significant difference only between CTG and CG (p=0.001). ATG and CG showed no differences (p>0.05) as shown in Table 04. There were no significant results for VO2max, flexibility and body composition in all groups.

Table 04 – Levels of strength on the 10RM.

	CG		ATG		STG		CTG	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
BENCH PRESS	12.5 (2.07)	12.5 (2.07)	15.70 (2.39)	13.70 (2.61)	17.43 (2.17)	19.50*† (1.92)	15 (1.83)	19*† (3.38)
Effect Magnitude	---------		0,83 Small		0,95 Small		2.18 Large	
LEG EXTENSION	37.5 (4.62)	37.5 (4.62)	40.00 (7.91)	42.00 (10.37)	40 (7.55)	47.37* (9.25)	36.87 (7.03)	54.37*† (3.20)
Effect Magnitude	---------		0,25 Trivial		0,97 Small		2,48 Large	

Note: 10RM test expressed in Kg; mean values, standard deviation and effect size;
* Significant and higher difference compared to pre-training period (p ≤ 0．0５)；
?Significant and inferior difference compared to CG (p≤０，０５)．

DISCUSSION

The purpose of this study was to verify and compare the effect of different types of exercise training on blood pressure, lipid profile, body composition and physical performance in hypertensive women. The main findings of this study were that ATG and CTG had chronic hypotension on SBP as well as STG on DBP and MAP. Our results showed that independent of type of exercise, physical activity is an intervention to treat high hypertensive woman.

Similarly to our results, the literature show that aerobic exercise can significantly reduce BP (acute or chronic effects) in hypertensive individuals (Laterza et al., 2007). In addition, Monteiro (2007), corroborated the findings of the current study regarding BP reduction on SBP in ATG (-6%) of 16 hypertensive women (56±3 years) under pharmacological treatment, who underwent a four-month aerobic exercise program. Souza et al. (2012) found no significant chronic PEH on DBP when studying a group of 13 sedentary subjects (46.8±3.4 years) who underwent 16 weeks of aerobic exercise, three sessions a week (50-60 minutes per session). These findings may be related to the low frequency of three sessions per week, since hypotension is usually reversible within 24 hours after a session. Then, more sessions per week are important factor for causing and keep a PEH (Williams et al., 2007; SBC, 2010).

Strength exercise can cause significant hypotension as presented in the current study concerning DBP and MAP. Similar results were observed in other studies (Figueiredo et al, 2015; Figueiredo et al., 2015; Simão, Salles & Polito, 2008; Terra, et al., 2008). PEH due to this type of training may be related to decreasing cardiac output. In addition, decreasing only 2mmHg in diastolic pressure after resistance exercises it is possible to reduce death risks associated with hypertension (Terra et al., 2008). On the other hand, Souza et al. (2012) assessed the chronic aspect of PEH in nine sedentary subjects (48.7±5.5 years) who underwent 16 weeks of strength training, and found no significant reduction in SBP and DBP. The lack PEH on SBP may be caused by the state of the vascular system of the sample. Due to body aging, arteries become stiffer and thicker with less vascular light, causing a greater resistance which inhibits vascular responses to vasodilators stimulated by exercising (Souza et al., 2012).

Simão et al. (2008) studied the BP chronic behavior after four months of concurrent training exercise in hypertensive individuals under medication control. Forty-eight sedentary men for 12 months were organized into two groups: concurrent training group (GTC, n=28) and control group (CG, n=20). The results showed that CTG decreased SBP by 5.8% ($p<0.05$) and DBP by 2.2% ($p>0.05$). in addition, Goodwin et al. (2009) also observed a reduction in BP, corroborating with current research that found a significant decrease in SBP, DBP and MAP.

Our results, showed significance for HDL on the lipid profile for ATG, STG and CTG. The variable LDL, even statistically insignificant, was reduced in the experimental groups post-intervention. However, CG presented a significant change by increasing LDL values. These results suggest that physical exercise helps to control biochemical markers and improves the lipid profile of hypertensive women. Some studies show significant reductions in LDL using aerobic exercise (Molena-Fernandes, 2008; Marcon et al., 2011), and strength training exercises (Marques et al., 2009; Shaw et al., 2010), so the physical exercise performance can improve the lipid profile (Rosetti, Britto & Norton, 2009). One of the study limitations was the lack of dietary control, because regular exercise combined with healthy eating habits tends to improve LP and reduce the risks of cardiovascular diseases (Fagherazzi & Bortolon, 2008).

In the present study, no significant differences were found in intragroup and intergroup analysis for anthropometric variables, and if the current study would have applied any nutritional control, the results could be different. The improvement in body composition and strength is important for good health and quality of life, and this should be sufficient for an individual to perform daily tasks efficiently. In this study, there was a significant increase in muscle strength in CTG and STG. In this way, one limitation of this study was to perform only three sessions a week. It is recommended that the weekly frequency with more sessions for significant change in body composition (Laterza et al., 2007).

CONCLUSIONS

In general, our results showed that different types of exercises can be performed in order to control BP and lipid profile in hypertensive patients, providing a variety of motor activities for the occurrence of acute and chronic post-exercise hypotension. More research is necessary to analyze the variables investigated in this study, concerning acute and chronic hypotension on hypertensive women, with nutritional education and diet.

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258/34 Raviwar Peth Solapur-
413005,Maharashtra
Contact-9595359435
E-Mail-ayisrj@yahoo.in/ayisrj2011@gmail.com