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Post-Exercise Hypotension Attenuates the Effect of Waist on Vascular Reactivity in Adults of Both Sexes

Ricardo A. C. Souza, Reginaldo L. Nascimento, Janine A. Souza, Camila M. M. Almeida, Ana Angélica S. Silva, Ferdinando O. Carvalho, José Fernando V.N. Moraes, Sérgio R. Moreira

College of Physical Education (CEFIS), Federal University of Vale do São Francisco (UNIVASF), Petrolina-PE, Brazil

ABSTRACT

Souza RAC, Nascimento RL, Souza JA, Almeida CMM, Silva AAS, Carvalho FO, Moraes JFVN, Moreira SR. Post-Exercise Hypotension Attenuates the Effect of Waist on Vascular Reactivity in Adults of Both Sexes. **JEPonline.** 2012;15(1):87-97. Measurement of the waist circumference has been highlighted as a major factor in increased risk of vascular reactivity and therefore the occurrence of hypertension throughout time. On the other hand, studies investigating the acute effects of exercise on blood pressure have shown the phenomenon of post-exercise hypotension (PEH). The purpose of this study was to analyze the relationship between the waist circumference and vascular reactivity, and to verify if PEH (after a combined exercise session) attenuates this relationship. Fifty adults of both sexes (28.8 ± 7.1 yr; 73.3 ± 13.3 kg; 172.9 ± 8.8 cm) volunteered to perform measurements of waist circumference and vascular reactivity of blood pressure. In addition, 20 individuals (10 males and 10 females; 33.4 ± 6.9 yr, 70.2 ± 15.8 kg, 170.4 ± 11.5 cm) performed a combined session of resistance and aerobic exercise with duration of 36 min and a control session without exercise on the same period of different days and in randomized order. The vascular reactivity was analyzed by the Cold Pressor Test, which was applied at rest to all the subjects (n = 50) and 1 hr after the experimental sessions (n = 20). The findings indicate that there is a relationship between waist circumference and vascular reactivity during (r = .49/.53; P<0.01) and after (r = .52/.55; P<0.01) the Cold Pressor Test. Also, a single combined exercise session at moderate intensity enabled PEH and attenuated the influence of waist circumference in increasing vascular reactivity in adults of both sexes.

***Key Words**:* Combined Exercise, Waist Circumference, Vascular Reactivity Reduction, Cardiovascular Risk

INTRODUCTION

The prevalence of overweight and obesity has increased in the population throughout the world (18). Excessive body fat is an important risk factor for cardiovascular diseases (CD), such as hypertension (5,7,22). Classically, hypertension has been associated with an increased vascular reactivity (VR) during and after acute moments of stress (13,31). A significant increase in VR can suggest an impaired autonomic modulation and enhanced sympathetic tone; a phenomenon associated to medium- and long-term CD risk (9,27), which is positively associated with body fat (14,20).

Several body fat indicators are used by health practitioners. In particular, the waist circumference has been considered as an important risk factor in the development of hypertension (21,29). Christou and colleagues (7) demonstrated that, independently and in a higher degree than aerobic fitness, the waist circumference is associated with hemodynamic risk factors. This means that the cardiovascular protection induced by the level of aerobic fitness has been considered modest when compared to body adiposity. These results suggest the need of more investigation through acute strategies in the attenuation of cardiovascular risk and blood pressure (BP) control.

The maintenance of BP in values considered as average includes performing exercise (12). Studies have investigated the acute benefits of aerobic (10,17), resistance (8,23) and combined (28) exercise in healthy and pathological individuals. These studies demonstrate an important effect of exercise in the hemodynamic control through post-exercise hypotension (PEH). In addition, other results reveal that after a single exercise session performed in the morning shift, a cardiovascular protection can last until the night's sleeping period (15).

Despite the highlighted benefits of exercise, the information on the effects of a combined exercise session (aerobic and resistance) on BP control, and its impact on the attenuation of induced stress, through variables like abdominal adiposity, are still made necessary. Thus, the aims of the present study were to analyze the correlation between the waist circumference and VR during and after a cardiovascular stress test, and to verify the influence of PEH in attenuating the effect of waist circumference in VR in adult individuals of both sexes.

METHODS

Subjects

In the initial phase, 50 apparently healthy subjects of both sexes with age between 17 and 50 yr (28.8 ± 7.1 yr), weight varying from 45 to 105 kg (73.3 ± 13.3 kg), and height ranging from 149 to 192 cm (172.9 ± 8.8 cm) volunteered to participate in the study. In the latter phase, which involved the experimental procedures (exercise session), 20 subjects of both sexes were selected (10 men and 10 women) with age between 24 and 50 yr (33.4 ± 6.9 yr), weight varying from 45.0 to 95.5 kg (70.2 ± 15.8 kg), and height ranging from 149 to 192 cm (170.4 ± 11.5 cm). The university's ethics committee approved the research (protocol number CAAE – 0047.0.441.000-10), and all subjects were informed of the adopted procedures and signed an informed consent form (as required by the resolution number 196/96 of the Brazilian National Human's Health and Research Council).

Procedures

To fulfill the objectives of the study, the subjects were invited to participate in waist circumference and VR measurements during and after a cardiovascular stress test (n = 50), and two experimental sessions. The first experimental session consisted of a combined aerobic and resistance exercise. The second session (i.e., one control session) was performed on different days and in randomized order with measurements of BP and VR 1 hr after the sessions (n = 20).

Anthropometric Variables
Body weight was measured using a digital scale (Tech Lyne, Petrolina – PE, Brazil) with a 0.1 kg precision. In order to obtain the subject's height, a metallic stadiometer (Physical, Londrina – PR, Brazil) with a 0.1 cm precision was used. Waist circumference was measured between the last rib and the anterior superior iliac crest, as described by Callaway et al. (4), with an inextensible metallic tape (Cescorf, Porto Alegre – RS, Brazil) with a 0.1 cm precision.

Assessment of Blood Pressure (BP)
An experienced evaluator measured BP using the auscultatory method, as suggested by Perloff et al. (19). A stethoscope (Duo Sonic, BD, Juiz de Fora – MG, Brazil) and a calibrated sphygmomanometer (Missouri, São Paulo – SP, Brazil) were used. All measurements were performed using the left arm with the subject seated in a calm and comfortable place.

The evaluator responsible for the BP measurements was submitted to a validation procedure of the adopted auscultatory measurements. In order to do this, a clinically validated automatic device (25) (Microlife BP3AC1-1, Co, USA) was used. The validation procedure involved 30 volunteers of both sexes. Each volunteer remained seated for approximately 10 min, and then had his/her systolic blood pressure (SBP) and diastolic blood pressure (DBP) measured by both the automatic and auscultatory methods, in a randomized order. The measurements using the automatic device were performed by a different researcher, so that the evaluator responsible for the BP measurements by the auscultatory method would not have access to the results. The correlations found between the two methods for SBP and BDP were r = .90 (P=0.001) and r = .80 (P=0.001), respectively. In addition, Bland and Altman's technique (1) revealed agreement between the measurements taken. The difference of the mean was 3.9 (-12.4 / 20.2) and -3.4 (-17.3 / 10.5) for SBP and DBP, correspondingly, with a 95% confidence interval (Figure 1).

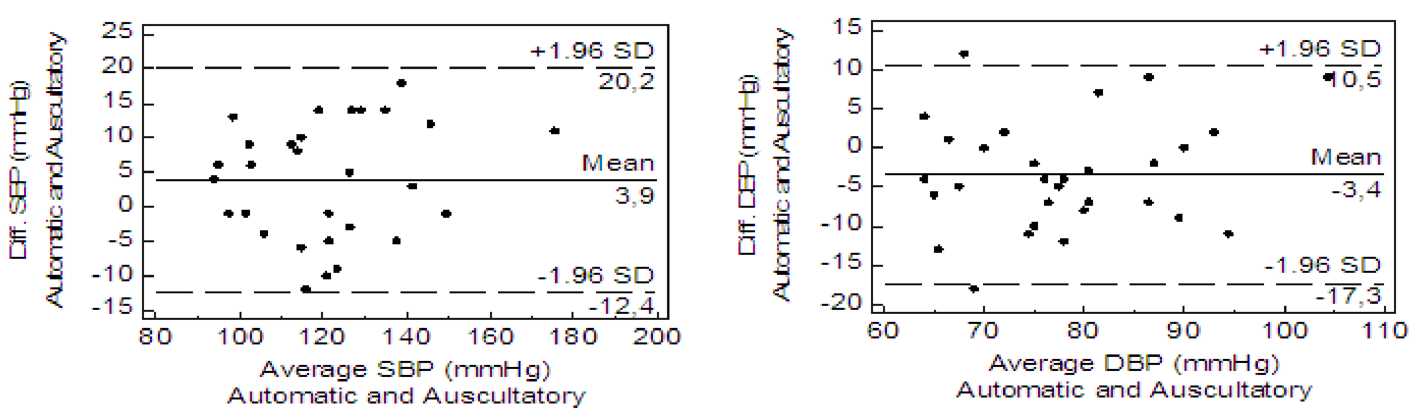

Figure 1. Bland and Altman technique (1) performed between the measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP) obtained by the auscultatory and automatic methods (n = 30).

Assessment of Vascular Reactivity
Vascular reactivity (VR) was measured using the Cold Pressor Test (CPT), following the previous procedures defined by Hines and Brown (13). These authors demonstrated the reproducibility of the CPT through measurements repeated after intervals that varied from 3 months to 3 yr in normotensive and hypertensive individuals. In addition, the specificity of the CPT was also verified by Bring and Oerting (3). The VR test protocol consists of immersing the right hand (up to the wrist) in a recipient with water at a temperature of 4ºC for 1 min. The temperature of the water was controlled using an analog thermometer (Incoterm®, Porto Alegre – RS, Brazil). Blood pressure (BP) measurements were performed at the 60th sec of the test by the auscultatory method using the

stethoscope and sphygmomanometer previously described. The peak values found during the VR test were considered as the BP's Ceiling 60" (13,31) and, then, 2 min after the CPT, another measurement was performed (Post 2'). It is important to highlight that our option for the auscultatory method was in consequence of the original protocol of the CPT that required measurements at the 60th sec mark of the test. This would make the use of the automatic method impracticable, since the equipment varies from 20 to 50 sec to perform one measurement.

Experimental Sessions (Combined Exercise and Control)

The subjects (n = 20) performed two experimental sessions in a randomized order, at the same time of the day, with a 48 to 72 hr interval. The "Exercise Session" consisted of three circuits of the following exercises: leg extension, bench press, leg curl, lying row, squat, shoulder press, and 5 min of stepping up-and-down on a 15 cm high wooden box. The duration of exercise session was 36 min. There was a 2 min recovery period between each circuit. The workload used for men and women were a pair of 6 kg and 3 kg dumbbells, respectively. For the lower limb exercises, a 4 kg weight was attached to each leg in both sexes, except for the squat. Every exercise set was composed of 15 repetitions and each repetition lasted 2 sec (1 sec in the concentric phase and 1 sec in the eccentric phase), which was controlled by a metronome (Metronome Plus®). The "Control Session" repeated all measurement procedures adopted during the exercise session, but there was no exercise.

Measurement of Variables during the Experimental Sessions

Resting SBP and DBP were measured four times during 20 min (one measurement at each 5 min) and the mean value was considered as the value at rest (Missouri, São Paulo – SP, Brazil). In addition, SBP and DBP were measured after each exercise circuit or control and four times during a period of 1 hr (at each 15 min) after the experimental sessions. The CPT was performed one hour after the experimental sessions. Heart rate (HR) was measured immediately after each type of exercise (aerobic or resistance) and at the control session's equivalent moment (Pulse Tronic Club Trainer®, Switzerland). All mean values for the HR measurements during the experimental sessions were considered to identify the cardiovascular workload imposed during exercise or control. Rate of perceived exertion (RPE) was also evaluated after each circuit and the mean value of the session was calculated (2) (refer to Table 3).

Statistical Analysis

Descriptive statistics (mean, standard deviation, minimum and maximum values) was performed. Normality of data was tested through Shapiro-Wilk's Test. Pearson's Correlation Test was used in order to verify the degree of association between BP at rest (automatic and auscultatory methods), as well as between VR and waist circumference in different conditions (rest, after exercise, and after control). The Bland and Altman's technique (1) was applied to attest the level of agreement between the BP measurements through the automatic and auscultatory methods. Student's t-test for repeated measures was used to compare the results obtained at the different experimental sessions (Exercise vs. Control). ANOVA two-way for repeated measures was also performed to compare the BP responses within and between the experimental sessions [Time (Pre vs. Post) * Session (Exercise vs. Control)]. The level of significance adopted was P=0.05 and the software used was the SPSS version 15.0.

RESULTS

Table 1 shows the mean values of waist circumference and BP at rest, during and after the VR test for the whole sample (n = 50). It is possible to observe that the CPT was efficient in inducing VR (P=0.05).

Table 1. Mean (± SD) values of waist circumference and blood pressure responses at rest, during and after vascular reactivity test (n = 50).

	Mean ± SD	Range
Waist Circumference (cm)	80 ± 10	60 – 107
SBP Rest (mmHg)	118 ± 10	94 – 144
SBP Ceiling 60” (mmHg)	135 ± 12*	102 – 162
SBP Post 2’ (mmHg)	119 ± 11	92 – 150
DBP Rest (mmHg)	79 ± 70	64 – 98
DBP Ceiling 60” (mmHg)	94 ± 10*	72 – 124
DBP Post 2’ (mmHg)	81 ± 10	66 – 116

SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; Ceiling 60”: Peak of blood pressure at the 60th second of the Cold Pressor Test; Post 2’: Two minutes after the Cold Pressor Test. *P=0.01 to rest of the same variable

When at rest, significant associations were found between waist circumference and BP at rest and VR during and after the CPT (Table 2).

Table 2. Associations (r) between waist circumference and blood pressure at rest and vascular reactivity (n = 50).

	Waist (cm)		Waist (cm)
SBP Rest (mmHg)	0.49*	**DBP Rest** (mmHg)	0.51*
SBP Ceiling 60” (mmHg)	0.49*	**DBP Ceiling 60”** (mmHg)	0.53*
SBP Post 2’ (mmHg)	0.55*	**DBP Post 2’** (mmHg)	0.52*

SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; Ceiling 60”: Peak of blood pressure at the 60th second of the Cold Pressor Test; Post 2’: Two minutes after the Cold Pressor Test; *P=0.01

Table 3 presents the subjects’ HR and BP responses at rest and during each circuit of the experimental sessions (exercise and control), as well as the RPE during the exercise session. The combined exercise session resulted in a cardiovascular workload of 79 ± 11% of the maximum HR for the subjects’ age and an RPE of 13 in a Borg Scale of 15 points.

Table 3. Mean (± SD) of hemodynamic and perceptual variables at rest and during exercise and control.

	Exercise	Control	P
Heart Rate Rest (beats·min^{-1})	80±10	78±12	0.30
Heart Rate Mean Session (beats·min^{-1})	147±21	76±11	0.01
Heart Rate Mean Session (% Heart Rate maximum)	79±11	41±5	0.01
RPE Mean Session (Borg Scale)	13±1	-	-

RPE: Rate of perceived exertion. P = comparison between Exercise and Control Sessions

The deltas of variation of the BP responses in both experimental sessions are shown in Figure 2. Post-exercise hypotension (PEH) of SBP was observed in all recovery moments after exercise (P=0.05), while DBP presented PEH only after 60 min of recovery (P=0.05). On the other hand, the control session showed an increase in DBP at the 45th and 60th min of recovery when compared to rest (P=0.05). In addition, a protective effect derived from exercise, when compared to the control, was observed in both SBP and DBP during all recovery moments (P=0.01).

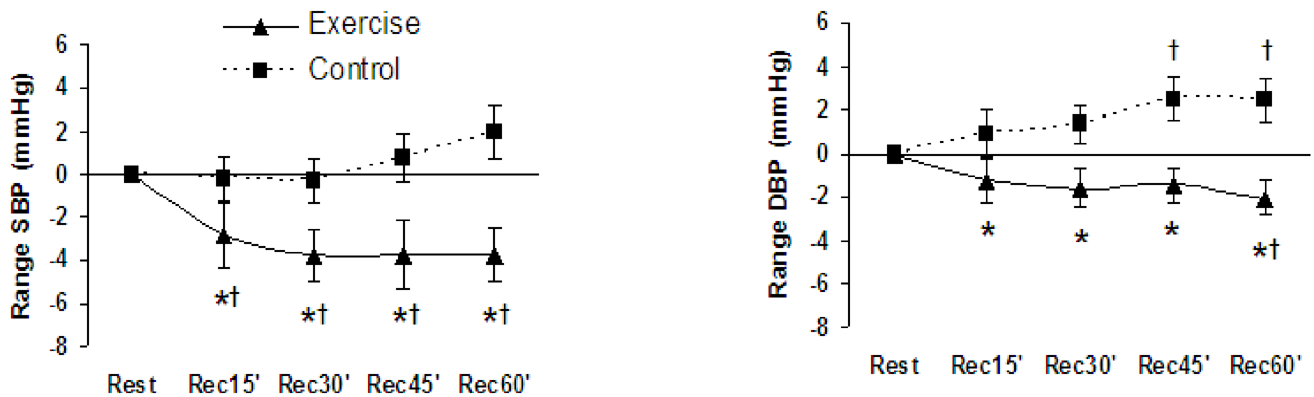

Figure 2. Variation between systolic blood pressure (SBP) and diastolic blood pressure (DBP) responses in different moments of recovery (Rec15'-Rec60') post experimental sessions (n = 20).
*P<0.01 to control; †P<0.05 to rest of the same session

The associations between waist circumference and VR during and after the CPT for both experimental sessions are presented in Figure 3. Similar to the results found in the sample with 50 individuals (Table 2), the results found in the control session were also significant (P=0.05). On the other hand, the associations ceased to exist after exercise (P>0.05), except for the DBP Ceiling 60", suggesting a protective effect of exercise.

DISCUSSION

The results demonstrate a significant association between the waist circumference and VR in both SBP and DBP during and after a cardiovascular stress test (Table 2). However, the main finding of the present study is that a combined aerobic and resistance exercise session resulted in PEH (Figure 2), and it attenuated the effect of waist circumference in VR of adult individuals of both sexes. To our knowledge, this is the first experimental study that associates VR responses after a combined aerobic and resistance exercise session with an indicator of abdominal adiposity.

Evidence of associations between BP and body adiposity have already been shown (21). Carneiro et al. (5), for instance, when analyzing overweight and obese individuals, found a significant increase in the prevalence of hypertension, especially in the participants with a body mass index = 30 kg.m$^{2(-1)}$, while Sarno and Monteiro (21) highlighted that an increase of fat in the abdominal region enhanced the risk of hypertension. These results corroborate with the findings in the present study, which present a positive significant association between BP values at rest and VR with the waist circumference of healthy adult individuals of both sexes (Table 2).

The mechanisms that explain the association of abdominal adiposity and VR can be partially explained. The increase of body fat is associated with a higher sympathetic nervous activity (14,20) and a possible activation of the angiotensin-renin system, which could decrease the bioavailability of nitric oxide and thus, increase the stiffness of the arteries and BP (7). In the present study, the waist circumference was associated with BP at rest and with VR induced by the Cold Pressor Test (Table 1), which acts through a possible neurogenic reflex and through the increase in the sympathetic tone (31). Kuniyoushi et al. (14) evaluated BP and sympathetic activation in eutrophic and obese women.

They also used the Cold Pressor Test and came to the conclusion that obesity increases sympathetic activiity and vascular resistance during an induced stress.

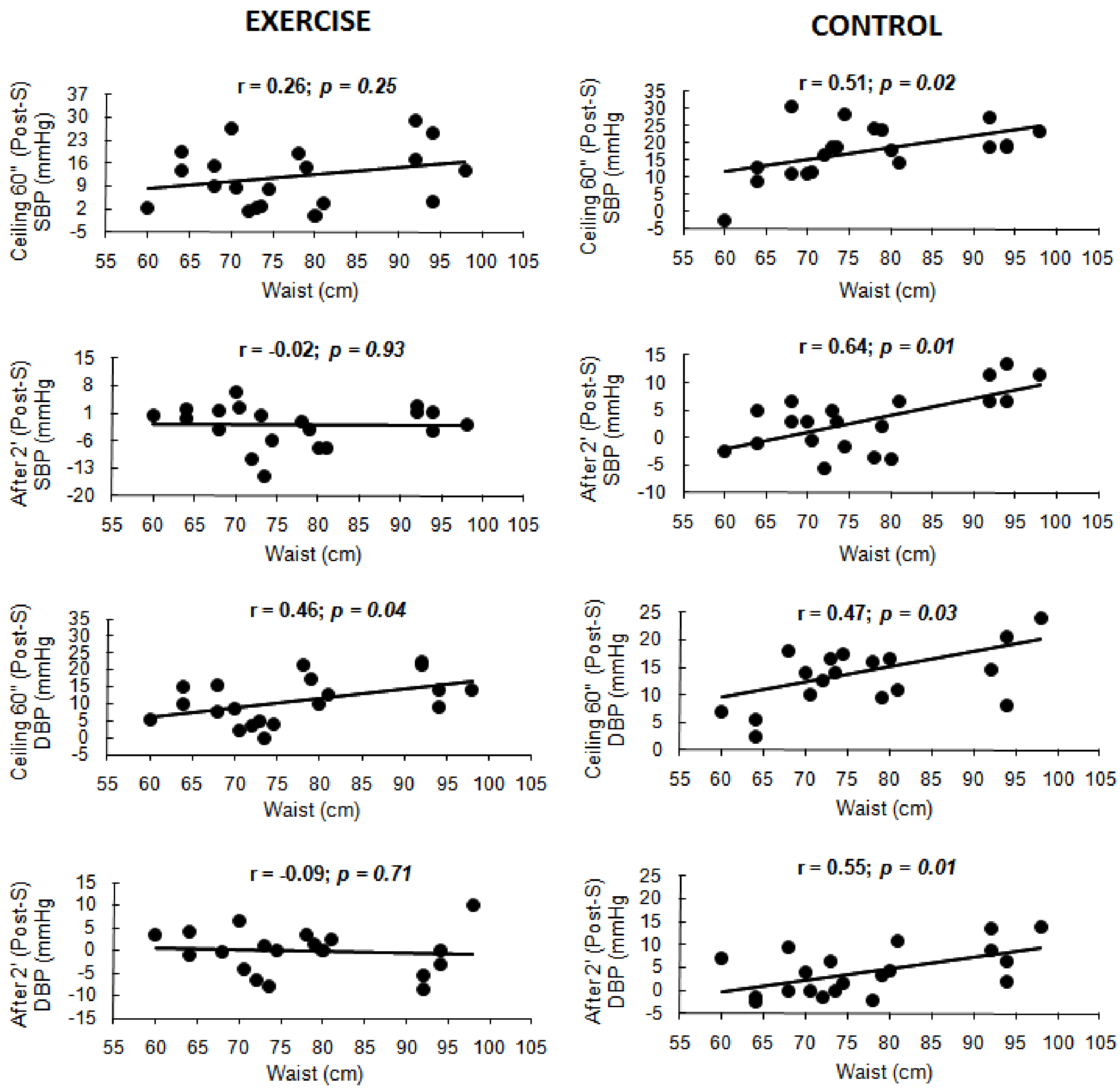

Figure 3. Association (r) between waist circumference and the variation of vascular reactivity of blood pressure during (Ceiling 60") and after (After 2') the Cold Pressor Test performed post-session (Post-S) (n = 20).

On the other hand, Christou et al. (7) found that the maximum oxygen uptake, a variable that could represent a chronic adaptation to training, did not present itself as an important predictor of hemodynamic risk factors when compared to body fat indicators, particularly with waist circumference. These results suggest that acute strategies can be used in the attenuation of hemodynamic risk and blood pressure control and bring practical application to the results found in the present study. Since there was a significant decrease of approximately 6 mmHg and 5 mmHg for SBP and DBP, respectively, after the combined exercise session (Figure 2). Whelton et al. (30) demonstrated that small alterations in BP, promoted throughout time, are capable of providing a significant impact in an individual's cardiovascular survival. Decreases in SBP of 3 mmHg and 5 mmHg can reduce in 8% and

14% the risk of myocardial infarction and in 5% and 9% the risk of coronary disease, as well as reduce overall mortality in 4% and 7%, respectively. These authors add that a decline of as much as 2 mmHg in both SBP and DBP can cut back in 6% and 14% the risk of myocardial infarction and in 4% and 6% the risk of coronary disease, correspondingly. This reduction of 2 mmHg in DBP can still decrease the prevalence of hypertension in 17% of the general population.

In addition, a combined aerobic and resistance exercise session can be used as a strategy to minimize, through PEH, the effects of risk factors, such as abdominal adiposity, on the VR of adults of both sexes. However, the mechanism that explains the effects of PEH as an attenuator of the association between abdominal adiposity and VR still needs to be established. The combined exercise protocol was able to acutely reduce BP during the recovery period. This could be explained by neural modifications which could result in a decrease of the sensibility of sympathetic nervous activation (6) and/or by metabolic alterations which result in the increase of vasodilators (17). Throughout time, these modifications could result in chronic adaptations with reduction in resting BP and a decrease in body fat itself (11,26). Thus, in consequence, these factors may be associated with VR, as shown in Table 2.

Regarding the intensity of the combined exercise session, it was possible to verify that even though the workload was standardized with weights varying only between sexes and not between exercises, the mean intensity shows a cardiovascular demand of 79 ± 11% of the maximum heart rate for the participant's ages. Still, during the combined exercise session, it was possible to identify a mean RPE of 13 ± 1 in a 15-point Borg Scale (Table 3). Other authors have investigated the effects of exercise on BP responses in different populations. Simões et al. (23) found that PEH occurred in diabetics at intensities between 23% and 43% of the maximum strength workload, where the RPE was around 13 to 14 in a 15-point Borg Scale. Motta et al. (17) observed a mean cardiovascular demand of 80% of the maximum heart rate and 13-point mean in the Borg Scale while investigating the effects of aerobic exercise at an intensity of 90% of the anaerobic threshold in the BP of adult individuals of both sexes. These results could be considered similar to the ones found in the present study. In this scenario, based on other studies that investigated RPE and blood lactate responses, and the indication of aerobic exercise (24) and resistance exercise (16) intensity, it is likely that the combined exercise session performed in the present study was in a moderate intensity.

A practical application of the results found in the present study can be the extension of this information to health practitioners who prescribe exercise to improve the cardiovascular health of the population. Therefore, individuals with similar characteristics to the subjects of the present study could perform combined exercise sessions at an intensity of 79% of their maximum heart rate, or at an RPE of 13 in a 15-point Borg Scale (2). In addition, when equalizing the utilized workload of the upper limb resistance exercises and squat to the participant's body weight, it is possible to suggest a workload of between 13% to 19% of the men's and 8% to 13% of the women's body weight. The same strategy can be used for the lower limb resistance exercises (except squat) using a workload of 8% to 13% of the men's and 11% to 18% of the women's body weight.

CONCLUSIONS

The findings in the present study support the relationship between waist circumference and vascular reactivity during and after induced stress. Moreover, a single combined exercise session at moderate intensity enables PEH and attenuates the effects of waist to increase the vascular reactivity in adults of both sexes.

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Address for correspondence: Souza RAC, Universidade Federal do Vale do São Francisco – Curso de Graduação em Educação Física – UNIVASF, Petrolina, PE, Brazil, 56.304-917. Phone +55 (87) 8827-1423; E-mail. banneric@gmail.com and sergio.moreira@univasf.edu.br

REFERENCES

1. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. ***The Lancet*** 1986;327:307-310.

2. Borg G. Ratings of perceived exertion and heart rates during short-term cycle exercise and their use in a new cycling strength test. ***Int J Sports Med*** 1982;3:153-158.

3. Bringgs JF, Oerting H. Vasomotor Response of Normal and Hypertensive Individuals to Standard Stimulus (Cold). ***Minnesota Med*** 1933;16:481.

4. Callaway W, Chumlea WC, Bouchard C, Himes JH, Lohman TG, Martin AD, et al. In: Lohman TG, Roche AF, Martorell R, editors. ***Anthropometric Standardization Reference Manual***. Champaign: Human Kinetics Books: 1988;39-54.

5. Carneiro G, Faria A, Ribeiro F, Guimarães A, Lerário D, Ferreira S, et al. Influência da distribuição da gordura corporal sobre a prevalência de hipertensão arterial e outros fatores de risco cardiovascular em indivíduos obesos. ***Rev Assoc Med Bras*** 2003;49:306-311.

6. Chen C, Bonham AC. Postexercise hypotension: Central mechanisms. ***Exerc Sport Sci Rev*** 2010;38:122-127.

7. Christou D, Gentile C, DeSouza C, Seals D, Gates P. Fatness is a better predictor of cardiovascular disease risk factor profile than aerobic fitness in healthy men. ***Circulation*** 2005;19:1904-1914.

8. Cucato G, Ritti-Dias R, Wolosker N, Santarem J, Jacob W, Forjaz C. Post-resistance exercise hypotension in patients with intermittent claudication. ***Clinics*** 2011;66:221-226**.**

9. Flaa A, Mundal H, Eide I, Kjeldsen S, Rostrup M. Sympathetic activity and cardiovascular risk factors in young men in the low, normal, and high blood pressure ranges. ***Hypertension*** 2006;47:396-402.

10. Forjaz C, Cardoso C, Rezk C, Santaella D, Tinucci T. Postexercise hypotension and hemodynamics: The role of exercise intensity. ***J Sports Med Phys Fitness*** 2004;44:54-62.

11. Foster-Schubert K, Alfano C, Duggan C, Xiao L, Campbell K, Kong A, et al. Effect of diet and exercise, alone or combined, on weight and body composition in overweight-to-obese postmenopausal women. ***Obesity*** *(Silver Spring)* 2011;14.

12. Gaesser A, Angadi S, Sawyer J. Exercise and diet, independent of weight loss, improve cardiometabolic risk profile in overweight and obese individuals. **Phys Sport**smed 2011;39:87-97.

13. Hines A, Brown E. The cold pressor test for measuring the reactibility of the blood pressure: data concerning 571 normal and hypertensive subjects. ***American Heart Journal*** 1936;11(1).

14. Kuniyoshi F, Trombetta I, Batalha L, Rondon M, Laterza M, Gowdak M, et al. Abnormal neurovascular control during sympathoexcitation in obesity. ***Obesity Research*** 2003;11:1411-1419.

15. Morais P, Campbell C, Sales M, Motta D, Moreira SR, Cunha V, et al. Acute resistance exercise is more effective than aerobic exercise for 24h blood pressure control in type 2 diabetics. ***Diabetes Metab*** 2011;37:112-117.

16. Moreira SR, Arsa G, Oliveira H, Lima L, Campbell C, Simões HG. Metthods to identify the lactate and glucose thresholds during resistance exercise for individuals with type 2 diabetes. ***J Strength Cond Res*** 2008;22:1108-1115.

17. Motta DF, Lima LC, Arsa G, Russo PS, Sales MM, Moreira SR, et al. Effect of type 2 diabetes on plasma kallikrein activity after physical exercise and its relationship to post-exercise hypotension. ***Diabetes Metab*** 2010;36:363-368.

18. Palou A, Serra F, Bonet M, Picó C. Obesity: molecular bases of a multifactorial problem. ***Eur J Nutr*** 2000;39:127-144.

19. Perloff D, Grim C, Flack J, Frohlich E, Hill M, McDonald M, et al. Human blood pressure determination by sphygmomanometry. ***Circulation*** 1993;88:2460-2470.

20. Ribeiro MM, Trombetta IC, Batalha LT, Rondon MU, Forjaz CL, Barretto AC, et al. Muscle sympathetic nerve activity and hemodinamic alterations in middle-aged obese women. ***Braz J Med Biol Res*** 2001;34:475-478.

21. Sarno F, Monteiro CA. Importância relativa do Índice de Massa Corporal e da circunferência abdominal na predição da hipertensão arterial. ***Rev Saúde Pública*** 2007;41:788-796.

22. Scherrer U, Randin D, Tappy L, Vollenweider P, Jéquier E, Nicod P. Body fat and Sympathetic Nerve Activity in Healthy Subjects. ***Circulation*** 1994;89:2634-2640.

23. Simões GC, Moreira SR, Kushnick MR, Simões HG, Campbell CS. Post-resistance exercise blood pressure reduction is influenced by exercise intensity in type-2 diabetic and nondiabetic individuals. ***J Strength Cond Res*** 2010;24:1277-1284.

24. Simões HG, Hiyane WC, Benford RE, Madrid B, Prada FA, Moreira SR, et al. Lactate threshold prediction by blood glucose and rating of perceived exertion in people with type 2 diabetes. ***Percep Mot Skil*** 2010;111:365-378.

25. Stergiou GS, Tzamouranis D, Protogerou A, Nasothimiou E, Kapralos C. Validation of the Microlife Watch BP Office professional device for office blood pressure measurement according to the International protocol. ***Blood Press Monit*** 2008;13:299-303.

26. Stasiulis A, Mockiene A, Vizbaraite D, Mockus P. Aerobic exercise-induced changes in body composition and blood lipids in young women. ***Medicina*** 2010;46:129-134.

27. Su TC, Lee YT, Chou S, Hwang WT, Chen CF, Wang JD. Twenty-four-hour ambulatory blood pressure and duration of hypertension as major determinants for intima-media thickness and atherosclerosis of carotid arteries. ***Atherosclerosis*** 2006;184(1):151-156.

28. Teixeira L, Ritti-Dias RM, Tinucci T, Mion Júnior D, Forjaz CL. Post-concurrent exercise hemodynamics and cardiac autonomic modulation. ***Eur J Appl Physiol*** 2011;111:2069-2078.

29. Tuan NT, Adair LS, Stevens J, Popkin BM. Prediction of hypertension by different anthropometric indices in adults: the change in estimate approach. ***Public Health Nutr*** 2010;13:639-646.

30. Whelton PK, He J, Appel LJ, Cutler JA, Havas S, Kotchen TA, et al. Primary prevention of hypertension: clinical and public health advisory from The National High Blood Pressure Education Program. ***JAMA*** 2002;288(15):1882-1888.

31. Wood DL, Sheps SG, Elveback LR. A cold pressor test as a predictor of hypertension. ***Hypertension*** 1984;3:301-306.