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Resistance exercise for elderly and hypertensive women: safety and postexercise hypotension

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Aim. The aim of the study was to investigate the impact of the moderate (60% of the 15RM) versus high (80% of the 15RM) workload of resistance exercise on cardiovascular response and postexercise hypotension (PEH) among elderly hypertensive women.
Methods. Twenty-one volunteers performed two sessions with the upper limbs (with moderate and light workload) and another two sessions with the lower limbs. Heart rate and the Adult OMNI Perceived Exertion Scale for Resistance Exercise (OMNI-RES) were measured during the exercises. The arterial blood pressure was measured before, during and at 50 minutes into the recovery period.
Results. The protocols with intensity at 80% of 15RM resulted in a perceived exertion at the end of each set, which was statistically higher than procedures with intensity at 60% of 15RM. This same phenomenon occurred both for upper- and lower-limb exercises. The double product was significantly higher in the high-intensity session than in the low-intensity session; however, none exceeded 17000 bpm x mmHg. The high-workload exercises promoted consistently higher PEH, in the lower and upper-limb exercises, respectively. The delta was -24 mmHg *versus* -14 mmHg for the systolic arterial pressure and -14 mmHg *versus* -9 mmHg for the diastolic arterial pressure.
Conclusion. The conclusion was that resistance exercises with high workload result in greater PEH without elevating the double product significantly.

Key words: **Hypertension - Resistance training - Hypotension.**

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A recent meta-analysis analyzing the effects of aerobic and resistance exercises on blood pressure in normotensive and hypertensive people showed that aerobic exercise resulted in hypotension (PEH)b of 2 to 12 mmHg in the systolic blood pressure and 2 to 9 mmHg in the diastolic blood pressure.[1] The same meta-analysis showed a hypotensive effect to resistance exercise of 3 to 12 mmHg in the systolic blood pressure and 3 to 7 mmHg in the diastolic blood pressure. It is notable that the data found in this study refer to moderate-intensity exercises such that it is as yet unclear whether the protocols with higher intensity are also capable of resulting in PEH.

In fact, the American College of Sports Medicine proposes in its guidelines that resistance exercise must be performed by hypertensive people with only a moderate workload (60% of 1RM)[2]. In 2007 recommendation by the American Heart Association, it is proposed that healthy elderly people can perform exercises with intensity superior to 60% of a set of 1RM.[3] The AHA recommendation also proposes that people with heart disease, regardless of age, must perform resistance exercises with less intensity. However, none of those recommendations suggests exercises for elderly hypertensive people who do not have other co-morbidities. A possible explanation for this is the scarcity of studies that evaluate safety and the best ways to prescribe resistance exercises to provide PEH in hypertensive elderly people.

The few studies that evaluate acute cardiovascular response among these people were performed with isometric and isokinetic exercises.[4-7] Likewise, it is unclear whether postexercise hypotension is affected by the workload of training with resistance exercises. Among the studies that compared the intensity of resistance training with acute cardiovascular response and the magnitude of postexercise hypotension,[8-11] none was performed with hypertensive elderly people.

Therefore, this study aimed to evaluate the impact of moderate versus high workload in resistance exercise on acute cardiovascular response and postexercise hypotension among hypertensive elderly women.

Materials and methods

Subjects

The study was conducted with 21 elderly women with mild hypertension according to the classification proposed by the ACSM.[12, 13] The size of the sample was determined according to Eng (2003). The present study estimated a difference of postexercise hypotension in the systolic pressure of 2 mmHg between exercises at 40-80% of 1RM, with a residual standard deviation of 2 mmHg.[14] A statistical power of 0.90 and an α-error of 0.05 were calculated for a minimum of 18 subjects who comprised the group. The G*Power software was used.

Subjects were physically active and participated in a program of resistance exercises for elderly people in the Federal University of Paraiba's gym. At the time of data collection, they had been training for approximately dois months. This study was approved by the Research Ethics Committee of the University Hospital Lauro Wanderley under the protocol number 135/10. Prior to the study, the participants signed a free and informed consent form according to Resolution 196/96 by the National Board of Health.

To participate in the study, the women needed to present only arterial hypertension as a function of cardiometabolic disease. As such, women with Body Mass Indices of over 30 kg/m^2, fasting glycemia of over 125 mg/dL, or with a disease related to the thyroid were excluded from the program, as well as those women who were not assiduous.

Experimental procedures

The elderly women performed two trainings per week with an interval of 48 hours between them. The conventional program of training for the women was interrupted for five weeks to ensure that the sessions were exclusive for the study. In the first week, all women participated in an educational session regarding suitable techniques for the movements for each exercise. They performed 10 repetitions with the minimum workload allowed by the equipment used in the study. During the same period, body mass and height were measured. Prior to the experimental protocols, the women were advised to avoid the consumption of caffeine-based food or drink for 12 hours before the collection. They were also advised not to perform physical activities in the 24 hours prior to the days of the study's exercise sessions.

In the following week, the test of anchoring for the OMNI-RES scale was performed,[15] and the 15RM test [16] was performed for six lower-limb exercises (leg extension, leg horizontal, leg 45, leg curl, abductor and adductor) and six upper-limb exercises (flat supine, low row, flying, front pulley, triceps and biceps) that would be used in the study. The workload was estimated after a maximum of three attempts for each exercise and with a minimum three-minute rest between each attempt. After 48 hours, another test was performed to confirm the results of the previous test.

The experimental protocols started in the third week, 96 hours after the test of strength. The women performed four sessions of resistance exercises, composed of two sessions for the upper limbs and two for the lower limbs, plus a control session. For each limb, a set was performed with the workload at 60% of 15RM and another at 80% of 15RM.The sessions were composed of three series of 15 repetitions each with a 10 minute interval between series and between exercises. In the control session, they remained seated in the fitness room for the same period as the sessions with exercise. The order of the protocols was individually and randomly determined (www.randomizer.org) in such a way that each subject had its own order for performing the five study protocols. All sessions were performed between 01:00 PM and 05:00 PM.

Heart rate and perceived exertion measurements

Heart rate was monitored by the Polar heart rate monitor, F11 model (Polar Eletro Oy, Kempele, Finland) and was registered at the end of each series exercises. To access the perceived exertion through the neurological component of force, the Adult OMNI Perceived Exertion Scale for Resistance Exercise (OMNI-RES) was used according to Lagally & Robertson.[17] The women reported their perception of effort at the end of each series of exercises at the moment when their heart rate was registered.

Arterial blood pressure measurement

Blood pressure was measured according to the recommendations of the American Heart Association [18] using an aneroid sphygmomanometer (BD – Minas Gerais, Brazil). As soon as they arrived for the session, the women were invited to remain seated for 10 minutes, and then, the resting blood pressure was measured. During the training sessions, blood pressure was measured at the end of the third series of each exercise, with the women voluntarily remaining in the equipment during the measurement. Therefore, they started the third series with the blood pressure cuffs on their arms in such a way that the blood pressure cuffs' inflation started at the penultimate repetition of this series. To measure blood pressure during the postexercise recovery period, the women were asked again to remain seated for 50 minutes, and new measurements were taken every 10 minutes in the recovery period.

Data processing and statistical analysis

The results are presented for the mean and the standard deviation of the mean. To compare heart rate, OMNI-RES and blood pressure responses for the lower- and upper-limb exercises on the 80% and 60% protocols were used, as well as the two-way ANOVA with repeated measures. When needed, the Turkey's *post hoc* test was performed. The confidence level was 5%. These procedures were performed using the Graphpad Instat software, version 3.06 (GraphPad Software Inc, San Diego, CA, USA).

Results

In the five days of procedures, the women showed similar basal values of arterial blood pressure and heart rate. All of them were mildly hypertensive and used antihypertensive medication (betablocker, angiotensin-converting enzyme inhibitors and diuretics). Among the 21 women, 15 used two of those drugs simultaneously, while 6 used only one. All of them took medication only in the early morning. They presented average values for blood glucose, slightly

TABLE I.—*Cardiovascular, anthropometric, biochemical, metabolic and drug characteristics of the studied subjects.*

	Hypertensive (N.=21)
Age (years)	60.2 ± 3.8
BMI (kg/m²)	28.7 ± 1.2
Glucose (mg/dL)	105 ± 7.1
Triglyceride (mg/dL)	191 ± 9.2
Cholesterol (mg/dL)	236 ± 10
HDL (mg/dL)	40 ± 6.2
LDL (mg/dL)	167 ± 8
VLDL (mg/dL)	25 ± 8
TSH (mUI/mL)	2.4 ± 0.5
T3 (ng/dL)	105.2 ± 3.7
T4 (ng/dL)	0.92 ± 0.1

	MI60%	MI80%	MS60%	MS80%	SC
SAP (mmHg)	142.9 ± 4.1	141.1 ± 3.7	142.2 ± 3.7	140.8 ± 3.8	142.3 ± 4.1
DAP (mmHg)	92.4 ± 3.9	90.3 ± 3.1	93 ± 3.6	91 ± 3.1	90.1 ± 3.8
HR (bpm)	73 ± 3.7	71.5 ± 3.4	72.8 ± 3	73 ± 3.4	78 ± 3.7
Drug	Diuretic N.=15	ACEI N.=8	Betablocker N.=13	Monotherapy N.=6	Politherapy N.=15

The data are presented with averages and standard deviations; kg: kilogram; BMI: Body Mass Index; HR: heart rate; bmp: beats per minute; SAP: systolic arterial pressure; DAP: diastolic arterial pressure; mmHg: millimeters of mercury; ACEI: angiotensin-converting enzyme inhibitor; TSH: thyroid-stimulating hormone; T3: triiodothyronine; T4: thyroxin.

over the superior level of normality, but none of them were diagnosed as diabetic or as having basal blood glucose superior to 125 mg/dl. Total cholesterol and triglycerides were high, and the average values for HDL cholesterol were around the minimum recommended. TSH, T3 and T4 hormones indicated that thyroid function was normal. All of this information is summarized in Table I.

Performance of the training protocols with intensity at 80% of 15RM resulted in a perceived exertion at the end of each set, which was statistically higher than procedures with intensity at 60% of 15RM (Figure 1). This same phenomenon occurred both for upper- and lower-limb exercises, indicating that the OMNI-RES scale confirmed that the training at 80% was perceived by the elderly women as more intense.

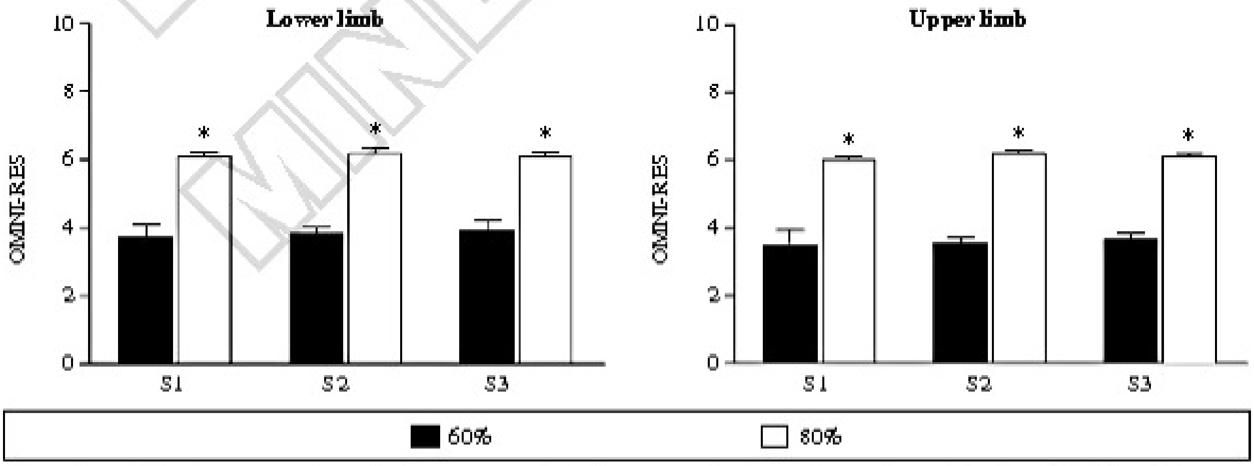

Figure 1.—Subjective perception of effort reported in the protocols of exercise with workload at 60% (black) *versus* 80% (white) of 15RM in sessions of resistance exercises for lower and upper limbs. The data represent the mean and standard deviation. * indicates statistical difference between the protocols at 80% and at 60% of 15RM for P<0.001.

Regarding heart rate, higher values were found for exercises at 80% of 15RM compared with 60% of 15RM only for upper-limb exercises. However, the systolic blood pressure and the double product were higher in the 80% of 1RM protocols, both for upper and lower-limb exercises. Figure 2 shows details of those data.

Figure 3 demonstrates that the protocols with two different workloads of exercise resulted in a significant reduction of blood pressure in the postexercise recovery period compared to basal values for both upper and lower-limb exercises. This PEH was consistently more evident in the protocols with 80% workload of 15RM both for systolic and diastolic arterial pressures.

The sessions of lower-limb exercises pre-

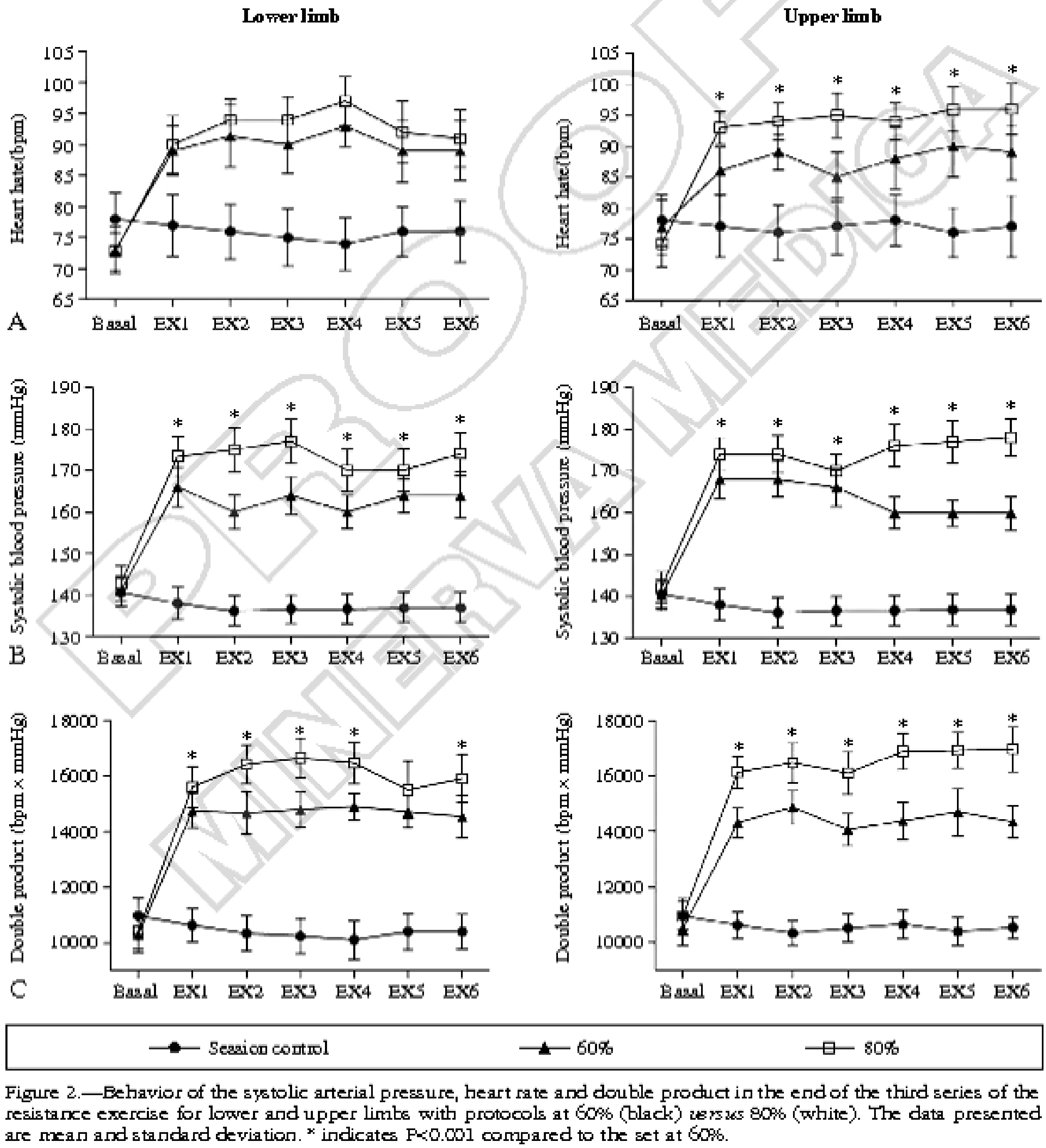

Figure 2.—Behavior of the systolic arterial pressure, heart rate and double product in the end of the third series of the resistance exercise for lower and upper limbs with protocols at 60% (black) *versus* 80% (white). The data presented are mean and standard deviation. * indicates P<0.001 compared to the set at 60%.

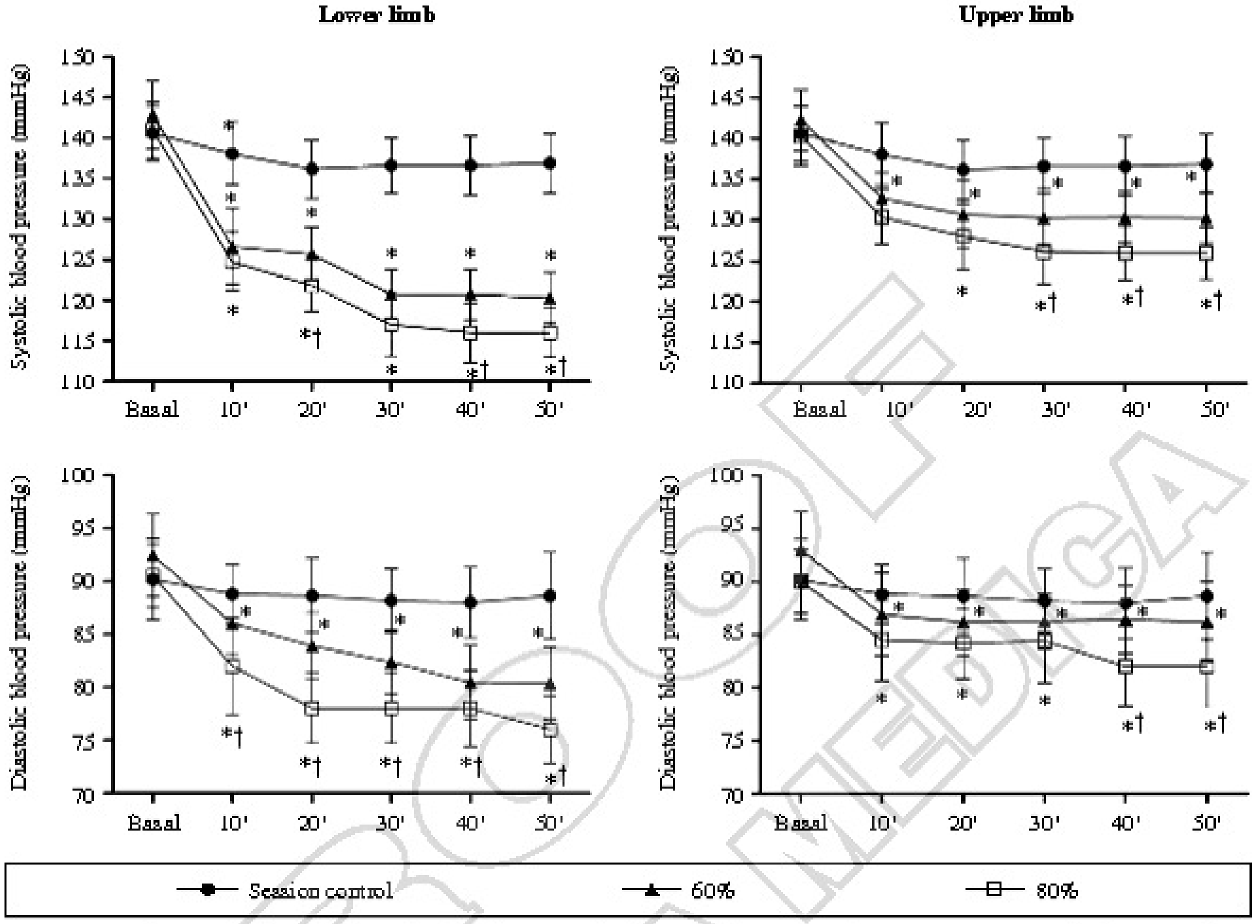

Figure 3.—Behavior of the Systolic and Diastolic Arterial Pressures in sessions of resistance exercise for lower and upper limbs with protocols at 60% (black) versus 80% (white). The data presented are the mean and standard deviation. * indicates P<0.001 compared to basal values, † means P<0.05 compared to the set at 60%.

sented higher postexercise pressure reductions compared to the upper-limb exercise sessions. In the protocols with 80% workload of 15RM, the delta was -24 mmHg *versus* -14 mmHg for the systolic arterial pressure (P<0.001) and -14 mmHg *versus* -9 mmHg (P<0.001) for the diastolic arterial pressure in the lower and upper-limb exercises, respectively. In the protocols with 60% of 15RM, the delta was 22 mmHg *versus* 13 mmHg for the systolic pressure (P<0.001) and 13 mmHg *versus* 7 mmHg (P<0.001) for the diastolic pressure in the lower and upper-limb exercises, respectively.

Discussion

The data of this study showed that moderate or high workloads are able to promote PEH with significant magnitude. However, the PEH magnitude was significantly higher for exercises performed at 80% of 15RM compared with exercises performed at 60% of 15RM. Moreover, it was shown that lower-limb exercises promote higher systolic and diastolic blood pressure reductions compared with the upper-limb exercises in both workloads adopted in this study.

Previous investigations have proven the effectiveness of resistance exercises in promoting PEH.[19, 20] However, those exercise protocols only used moderate workloads. The PEH magnitude in our study confirms the findings of the previous studies but only for the upper-limb exercises performed with moderate workload. When the session was performed with lower-limb exercises, the pressure reduction values increased to 22 mmHg and 13 mmHg for the systolic and diastolic pressures, respectively. In fact, our data corroborate that of Polito and Farinatti,[21] who have recently shown that resistance exercises for lower limbs promote PEH with a magnitude meaningfully higher than exercises for upper limbs in healthy normotensive young people. Nevertheless, the present study is the first time that such phenomena are shown with elderly hypertensive women. As Polito and Farinatti,[21] the authors also explain the higher PEH in lower-limb exercises due to the higher muscle mass involved in those exercises compared to upper-limb exercises.

Regarding the intensity of workloads adopted in the exercises, the great majority of studies of elderly hypertensive people available were performed with moderate workloads. Rezk *et al.*[10] and Brown *et al.*[8] observed PEH in healthy young subjects with similar magnitude to those found in the present study in moderate-intensity versus high-intensity exercises. However, O'Connor *et al.*[9] and Focht and Koltyn [22] have not observed the PEH phenomenon in young subjects, indicating a conflict in the current literature. Moreover, when all this authors used a higher workload, a reduction in the number of repetitions was observed compared with less intense workload sessions so that the total amount of work was not higher in the exercises with higher intensity. In our protocol, the amount of training (number of series, repetitions per series and intervals) was rigorously similar so that the only variable that may have influenced the PEH was the workload used in the exercises, because we kept the same number of repetitions for the exercises protocols with 60% and 80% of 15RM. This was an aspect that distinguished our exercise protocol from what had been shown in the previous studies, in addition to the present study being the only one in which the comparison between intensities was made with a population of hypertensive people. Therefore, it can be assumed that for an equal amount of work, the training with resistance exercises at higher intensities is more effective in promoting PEH in hypertensive elderly subjects.

The practical applicability of our data is conditioned to the possibility of safety of the resistance exercise with workload at 80% of 15RM for the elderly. The ACSM recommends that hypertensive elderly people practice resistance exercises of moderate intensity.[13] The American Heart Association, in turn, proposes the practice of such modality with workload superior to 60% of 1RM, only for healthy elderly individuals.[3] Nonetheless, many recent studies have adopted workloads between 60% and 80% of 1RM, even with hypertensive elderly, without any cardiovascular episode being reported.[23-25]

The double product responses found in our study support the safety of the exercise with high workloads. The values of the double product in the exercises with high intensity were significantly higher than the values observed in the exercises with moderate intensity, but they never exceeded 17000 bpm x mmHg. Making a comparison, Vacanti, Sespedes & Sarpi Mde [26] found a double product of 24945.6 bpm x mmHg after performing the ergonomic test on elderly individuals. The result was that, at least regarding the myocardial effort, the resistance exercises with workload at 80% of 15RM seem to be safe for the hypertensive elderly who have controlled arterial blood pressure and who have previously practiced resistance exercises.

A limitation of our study is that the women performed a single set of exercises with high intensity. Such limitation might be minimized by adopting sessions of repeated training so that cardiovascular response to many weeks of training is controlled. Similarly, it is known that the muscle recovery in elderly people is slower than that of younger subjects. Thus, even if the cardiovascular repercussions are healthy, more investigation is needed regarding the maintenance of a training protocol with intense workload for many sessions without presenting symptoms of chronic fatigue (overreaching or overtraining). These issues are based on investigation to provide future effective and safe methodologies for prescription of training with resistance exercises for elderly people.

Conclusions

Considering the present concept that resistance exercises be adopted as a tool for controlling arterial hypertension, our study adds the following new information: sessions with high intensities increase the postexercise hypotensive effect that is already known as a response to the resistance exercise with moderate workload practiced by hypertensive elderly people.

Riassunto

Esercizio di resistenza in donne ipertese e anziane: sicurezza e ipotensione post-esercizio

Obiettivo. Obiettivo del presente studio è stato quello di esaminare l'impatto del carico di un esercizio di resistenza a intensità moderata (60% del 15RM) *vs.* intensità elevata (80% del 15RM) sulla risposta cardiovascolare e sull'ipotensione post-esercizio (IPE) in donne anziane ipertese.

Metodi. Ventuno volontarie hanno realizzato due sessioni con gli arti superiori (carico di lavoro leggero e moderato) e due sessioni con gli arti inferiori. La frequenza cardiaca e lo sforzo percepito secondo la scala OMNI per l'esercizio di resistenza negli adulti (OMNI-RES) sono stati misurati durante gli esercizi. La pressione arteriosa è stata misurata prima, durante e dopo 50 minuti di recupero.

Risultati. I protocolli con intensità all'80% del 15RM si sono tradotti in uno sforzo percepito al termine di ciascuna che era serie statisticamente più elevato rispetto alle procedure con intensità al 60% del 15RM. Questo stesso fenomeno si è verificato sia per gli esercizi con gli arti superiori sia per quelli con gli arti inferiori. Il doppio prodotto era significativamente più elevato nella sessione ad alta intensità rispetto alla sessione a bassa intensità; tuttavia, nessuna ha oltrepassato i 17000 bpm x mmHg. Gli esercizi ad alto carico di lavoro hanno causato sistematicamente una IPE più elevata, rispettivamente negli esercizi con gli arti inferiori e in quelli con gli arti superiori. Il delta era -24 mmHg rispetto a -14 mmHg per la pressione arteriosa sistolica e -14 mmHg rispetto a -9 mmHg per la pressione arteriosa diastolica.

Conclusioni. Concludiamo dicendo che gli esercizi di resistenza con carico di lavoro elevato producono una IPE maggiore senza alzare il doppio prodotto in maniera significativa.

Parole chiave: Ipertensione - Resistenza, allenamento - Ipotensione.

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