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Acute blood pressure changes are related to chronic effects of resistance exercise in medicated hypertensives elderly women

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Summary

Background A previous study observed that the chronic effects of aerobic training on blood pressure (BP) are related to acute BP responses after a single bout of aerobic exercise. However, whether similar responses are observed with resistance exercise (RE) remains obscure. Thus, this study analysed the relationship between the acute BP responses to a single bout of RE and chronic changes in resting BP after a RE training in medicated hypertensive elderly women.

Methods and results Twenty medicated hypertensive women participated in the study. They underwent an acute RE bout where BP and heart rate (HR) were obtained at rest and for 60 min after the RE. Subsequently, the participants underwent a progressive RE training for 12 weeks at 60–80% of maximal strength test. Resting BP and HR were also obtained after the RE training. The chronic decreases in systolic and diastolic BP were significantly greater in the participants who experienced acutely decreased systolic and diastolic BP, respectively ($P<0·05$). The changes in systolic BP after acute RE were correlated with the chronic changes in resting systolic BP after RE training ($r = 0·47$; $P = 0·03$). Similar correlations between acute and chronic responses were also observed for diastolic BP ($r = 0·70$; $P = 0·01$), mean BP ($r = 0·58$; $P = 0·01$), HR ($r = 0·73$; $P<0·01$) and RPP ($r = 0·52$; $P = 0·01$).

Conclusion Similar to previously work involving aerobic exercise, BP responses to a single bout of RE are strongly related to chronic effects of RE training on BP in medicated hypertensive elderly women.

Introduction

Hypertension is a major public health problem in adult and elderly population. Specifically, in the later group, the relevance of hypertension in women has been growing, because there are more women than men in this age group (Go *et al.*, 2014).

Exercise has been widely recommended as an important therapeutic intervention in hypertensive subjects. In elderly, which are known to present reductions in strength, power and muscles mass, resistance exercise has been recommended as part of a comprehensive exercise programme (Pescatello *et al.*, 2004), because it promotes several benefits to physical fitness, including gains in muscular mass (Verdijk *et al.*, 2009), strength (Beneka *et al.*, 2005) and power (Caserotti *et al.*, 2008).

The effects of RE on blood pressure (BP) have been extensively studied in the past years (Cornelissen & Smart, 2013). Studies have consistently shown that a single bout of RE decreases BP to lower levels than observed at rest, and this reduction may persist for several hours, especially in women with hypertension (Melo *et al.*, 2006; Mota *et al.*, 2013a,b). In addition, the acute effects of RE on BP seem to be distinct between genders, being marked by the reduction in cardiac output in men, while in women, it seems to occur via reduction in systemic vascular resistance (Queiroz *et al.*, 2013).

On the other hand, the chronic effects of resistance training on BP are unclear; however, there is evidence indicating that chronic RE in women can lower resting systolic BP and rate pressure product (RRP; Terra *et al.*, 2008). A previous study observed that chronic effects of aerobic training on BP are related to acute BP responses after a single bout of aerobic exercise (Liu *et al.*, 2012). However, whether similar responses are observed with RE remains obscure, especially in elderly medicated hypertensive women. An understanding of how acute responses to RE are related to chronic effects is very useful in providing information about the individuals who are most likely to obtain cardiovascular benefits from chronic exercise practice. This information becomes even more relevant when studied in elderly populations, because of the increased cardiovascular risk factor from hypertension with ageing (Vega & Bisognano, 2014).

Thus, the primary objective of this study was to (i) assess the changes in BP before and after acute and chronic RE and (ii) analyse the relation between the acute changes in resting BP after a single bout of RE and the changes in resting BP after RE training. We hypothesized that the magnitude of BP reduction after acute RE (single bout) would be predictive of reduction in BP after RE training.

Material and methods

Subject's recruitment and screening

Participants were recruited from churches, clubs and art schools and were included in the study if they met the following criteria: woman >60 years old, sedentary in the 6 months prior to the study, medical consent to perform exercise training, absence of chronic lung disease, controlled BP (<160/105 mmHg) and absence of electrocardiogram response suggestive of myocardial ischaemia during the exercise test.

This study was approved by the Joint Committee on Ethics of Human Research of the University (process 05/2007). Each participant was informed of the risks and benefits involved in the study and signed a written informed consent form before participation.

Considering a power of 90% and an alpha error of 0·05, and assuming a standard deviation of 3 mmHg, the sample size necessary to detect a mean reduction of 4 mmHg in BP after exercise was calculated to be 10 participants. Allowing for approximately 50% patient dropout, 23 patients were recruited for the study.

Experimental design

The experimental design of the study is presented in Fig. 1. First, to analyse the relation between the acute responses in BP after a single bout of RE and the magnitude of change in resting BP after resistance training, baseline measures of maximal strength were obtained in medicated hypertensive women. After this, they underwent a single bout with measurement of acute BP responses after RE. In addition, they underwent a progressive periodized resistance training programme for 12 weeks. Finally, the BP was obtained at rest after resistance training programme to correlate with previous measures of acute BP responses.

Procedures

Maximal strength test

The subjects underwent a maximal strength test (1-RM test) performed in lateral pull down, knee extension, chest press, leg abductor chair, knee flexion and 45-degree leg press using Kramer and Fry's protocol. To guarantee the correct execution of the exercises, patients underwent four familiarization sessions before the 1 RM test. In these sessions, they performed one set of 20 repetitions in each exercise with minimum weight allowed by the equipment.

Assessment of acute responses to RE

The acute experimental session was commenced between 7 and 8 am, and participants were instructed to have a light meal at least 2 h before arriving at the laboratory and not to ingest coffee, tea, cola or other stimulants thereafter. In addition, they were instructed to refrain from vigorous physical activity for the previous 48 h and from alcohol ingestion for the previous 24 h. Smokers were instructed not to smoke before testing sessions, and all participants continued to take their regular medication on experimental days. The participants stayed resting for 20 min in a seated position (preintervention period), and after this period, BP and heart rate (HR) were measured in triplicate using a digital automatic device (*Microlife*®, model BP 3AC1-1 PC, Microlife AG, Widnau, Switzerland) which is validated for hemodynamic measurements at rest according to the criteria of the British Association of Cardiology (Cuckson *et al.*, 2002). This pre-exercise data from the acute session were also used to analyse the chronic effects of resistance training on cardiovascular parameters.

Afterwards, participants moved to the exercise room and performed the acute RE session. The acute exercise session consisted of 10 exercises performed on specific resistance training machines (*Righetto Fitness* Equipment, São Paulo, Brazil) being lateral pull down, knee extension, chest press, leg abductor chair, knee flexion, shoulder abduction (w/dumbbell), standing calf raise, abdominal exercises, trunk extension

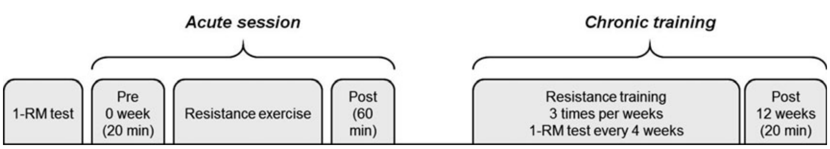

Figure 1 Experimental design of the study. BP, blood pressure; HR, heart rate.

and 45-degree leg press. At the beginning of the session, subjects completed 5 min of stationary cycling followed by stretching (light and self-selected intensity) of the major muscle groups to warm up. A personal trainer supervised all women throughout the duration of the exercise session. They were asked to complete three sets with 12 repetitions with 60% of 1-RM in each exercise with 60-s rest intervals.

After the intervention, participants returned to the laboratory, where they rested in the sitting position for 60 min (postintervention period), and BP and HR were measured in triplicate at 60 min, and the mean value was calculated. Moreover, was calculated the RPP by product of systolic BP by HR.

Resistance training programme

After the acute experimental session, participants started their resistance training programme, which was performed 3 days per week for 12 weeks. Before the beginning of the training, there was a 3-week adaptation period to guarantee the correct lifting techniques were used.

The resistance training programme was similar to that performed in the acute experimental session which consisted of 10 exercises, being lateral pull down, knee extension, chest press, leg abductor chair, knee flexion, shoulder abduction (w/dumbbell), standing calf raise, abdominal exercises, trunk extension and 45-degree leg press. At the beginning of each training session, the elderly women completed 5 min of stationary cycling followed by stretching (light and self-selected intensity) of the major muscle groups to warm up. They then completed three sets of each exercise with 8–12 repetitions. The load was progressively increased based on the 1-RM test performed after 4 and 8 weeks of resistance training. In the first 4 weeks, all REs were performed at 60% of 1-RM with 12 repetitions. Between the 5th and 8th weeks, exercises were performed at 70% of 1-RM with 10 repetitions. In the last 4 weeks, resistance training was performed at 80% of 1-RM with eight repetitions. During all training programmes, a 60-s rest interval was ensured between sets and exercises.

Assessment of chronic responses to RE

After 48 h following the last RE session, participants were assessed again for resting measurements of cardiovascular parameters. These measurements were performed using the same procedures as the pre-exercise measures in the acute experimental session. Thus, the measurements were performed between 8 and 9 am. The subjects stayed resting for 20 min in a seated position, and after this period, BP and HR were measured in triplicate.

Statistical analyses

Statistical analyses were performed using SPSS version 17.0 (SPSS Inc., Chicago, IL, USA). The primary variables of interest were systolic, diastolic, mean BP, HR and RPP after an acute bout of RE and chronic resistance training. Data were normally distributed as determined using a Shapiro–Wilk normality test, and for this reason, we used Pearson's correlations to assess the relationship between the acute and chronic changes in cardiovascular parameters. An additional analysis classifying subjects into those with or without decrease in BP was performed, and comparison between them was performed with a dependent t-test. Data are reported as mean ± standard error, and statistical significance was assumed at $P<0{\cdot}05$.

Results

Three women did not complete the training programme due to family problems ($n = 2$) and gallbladder surgery ($n = 1$). Clinical characteristics of the subjects are presented in Table 1. The subjects were mostly elderly, overweight and receiving antihypertensive medications.

The acute and chronic responses of cardiovascular parameters are presented in Table 2. With the exception of the HR, the subjects did not present acute reductions in BP, but exhibited chronic reductions in this variable. On the other hand, RPP decreased after both acute and chronic interventions.

The acute and chronic changes (Δ mmHg) in systolic and diastolic BP in each participant are presented in Fig. 2a,b. Eight of 20 women presented both acute and chronic reductions in systolic BP, while two patients presented acute and chronic increases in systolic BP. For diastolic BP, five of 20 women presented both acute and chronic reductions, while five subjects presented both acute and chronic increases in diastolic BP. The participants who presented acute BP reductions (responders) presented higher baseline systolic BP levels and similar age and weight compared to subjects who did not present acute BP reductions (non-responders; $P>0{\cdot}05$).

Table 1 Clinical characteristics of the subjects ($n = 20$).

Variables	Values
Age (years)	66·8 ± 5·6
Height (cm)	151·8 ± 7·9
Weight (kg)	65·0 ± 14·5
Body mass index (kg/m^2)	28·3 ± 5·8
Systolic blood pressure (mmHg)	125·2 ± 9·3
Diastolic blood pressure (mmHg)	72·0 ± 6·8
Mean arterial pressure (mmHg)	89·7 ± 6·9
Heart rate (bpm)	72·2 ± 12·0
Rate pressure product (mmHg*bpm)	9035·0 ± 1513·0
Antihypertensive medication	
β-blocker (%)	5·0
Associations with β-blocker (%)	30·0
Calcium channel blocker (%)	15·0
Angiotensin-converting enzyme inhibitor (%)	10·0
Diuretic (%)	10·0
Other associations (%)	30·0

Table 2 Average change (±SD and variation) to baseline on systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), heart rate (HR) and rate pressure product (RPP).

	Δ SBP (mmHg)	Δ DBP (mmHg)	Δ MAP (mmHg)	Δ HR (bpm)	Δ RPP (mmHg*bpm)
After acute	1·0 ± 5·3 (−7·7 to 15·7)	1·0 ± 5·4 (−14·3 to 14·4)	1·0 ± 4·2 (−9·0 to 10·5)	−4·3 ± 7·0* (−24·0 to 3·0)	−492 ± 889* (−2653 to 1267)
After chronic	−10·5 ± 9·8** (−33·7 to 3·7)	−1·0 ± 5·7 (−15·4 to 7·5)	−4·2 ± 5·7** (−15·9 to 3·2)	0·4 ± 8·0 (−17·0 to 14·0)	−2219 ± 1790** (−5621 to 475)

*$P<0{\cdot}05$ and **$P<0{\cdot}01$ in relation baseline values.

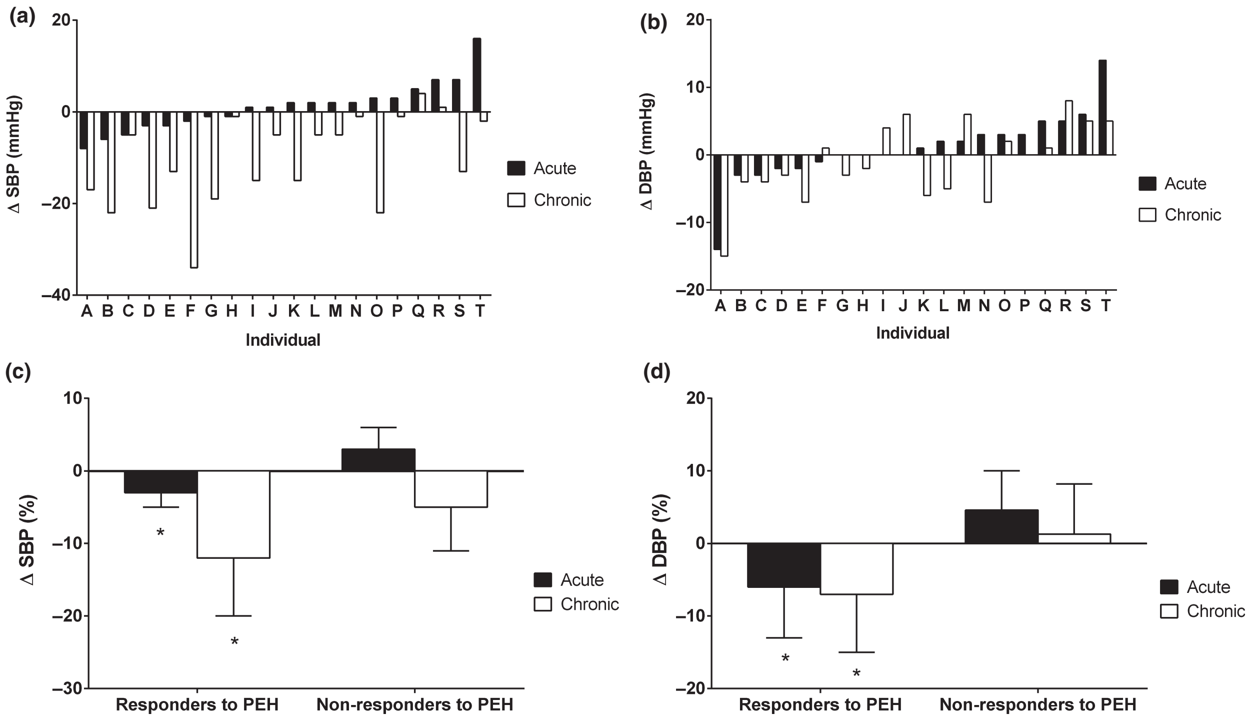

Figure 2 The individual acute and chronic systolic blood pressure (SBP) and diastolic blood pressure (DBP; upper) and comparison of acute and chronic responses between subjects with and without acute decreases in blood pressure (bottom). *$P<0{\cdot}05$ versus patients without acute and chronic decreases in blood pressure.

Figure 2c,d presents comparison of the acute and chronic responses between subjects with and without acute decrease in BP. The chronic decreases in systolic and diastolic BP were significantly greater in the subjects with acutely decreased systolic and diastolic BP, respectively ($P = 0{\cdot}029$).

The relationship between acute and chronic changes in systolic, diastolic and mean BP, and RPP is presented in Fig. 3. The changes in (Δ) systolic BP after acute RE were correlated with the chronic changes in systolic BP after resistance training ($r = 0{\cdot}47$; $P = 0{\cdot}03$). Similar correlations between acute responses and chronic adaptations were also observed for diastolic BP ($r = 0{\cdot}70$; $P = 0{\cdot}01$), mean BP ($r = 0{\cdot}58$; $P = 0{\cdot}01$), HR ($r = 0{\cdot}73$; $P<0{\cdot}01$) and RPP ($r = 0{\cdot}52$; $P = 0{\cdot}01$).

Discussion

The main findings of the present study are that the medicated hypertensive elderly women with decreased BP after a single bout of RE presented greater BP reductions after a chronic resistance training programme. In addition, our results showed a relationship between acute and chronic changes in BP, indicating that the magnitude of resistance training effect on BP is related to acute responses after a single bout of RE.

Significant chronic reduction in systolic BP after dynamic resistance training has occurred in the present study, which was higher than those reported in the literature for hypertensive subjects (Cornelissen & Smart, 2013). Interestingly, there was no average reduction in BP after a single bout of RE, which disagrees with other studies (Melo *et al.*, 2006; Mota *et al.*, 2013a,b; Queiroz *et al.*, 2013). This result was probably explained by high variability in the responses observed, caused by the different biological characteristics and pharmacological treatment therapies of the patients.

Studies have shown that RE can decrease BP both acutely (Pescatello *et al.*, 2004) and chronically (Terra *et al.*, 2008). The novelty of the present study is that a link between acute

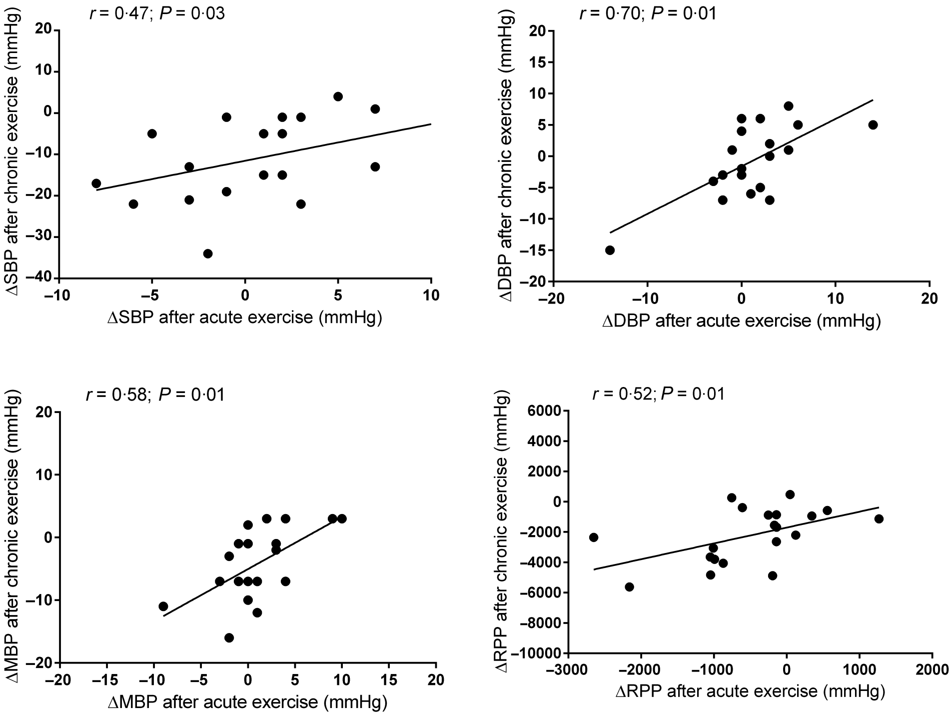

Figure 3 Relationship between the changes (Δ) of systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and rate pressure product (RPP) after acute exercise and chronic resistance training (*n* = 20).

and chronic BP responses to RE was observed in hypertensive medicated elderly women. The specific mechanisms linking acute and chronic BP responses after RE are unclear. During RE, there is an increase in production of metabolites (Bush *et al*., 1999) related to arterial muscle vasodilation. Moreover, RE promotes a shift of plasma fluid into the interstitial space, decreasing plasma volume and consequently stroke volume (Rezk *et al*., 2006). The repeated exposure to these acute central and peripheral stimuli may have stimulated adaptations in cardiovascular structure and control in a dose–response relationship leading to chronic effects on BP proportional to that observed after one single session of RE. However, due the greater relationship found between acute and chronic effects of RE on diastolic BP (r = 0·70; Fig. 3) as well as the greater consistency of response between responders and non-responders in relation to postexercise hypotension in diastolic BP more than in systolic BP, it is speculated that the mechanisms linking the acute and chronic responses in hypertensive elderly women are best represented by peripheral vascular resistance. In fact, a study conducted by Queiroz *et al*. (2013) observed that in women after a single bout of RE showed reduction of BP, which was explained by reduction in systemic vascular resistance. However, the mechanistic pathways for reducing BP after acute and chronic conditions in hypertensive elderly women were not studied and must be investigated in future studies.

The participants with acutely decreased BP presented higher chronic decreases in BP compared to the subjects without acute decreases in BP after RE, indicating that an acute response can mirror the chronic adaptation to exercise training. In agreement with previous studies (Moraes *et al*., 2012), the subjects who had greater acute BP decreases after RE presented higher systolic BP levels at rest, suggesting that BP baseline can be a potential factor related to chronic BP reductions after resistance training. Interestingly, the mechanisms underlying the occurrence of acute decrease in BP are still under debate. Although Santana *et al*. (2011) point to genetic factors from ACE I/D polymorphism that may play a role in lowering BP after aerobic exercise, another evidence with RE does not support the explanations from only one gene (ACE I/D polymorphism) in acute responses of BP (Mota *et al*., 2013a,b).

Our results showed that there is a significant correlation between acute responses in BP after a single bout of RE and chronic changes in BP after 12 weeks of resistance training. Liu *et al*. (2012) found strong and significant correlations (r = 0·89) between the acute decrease in systolic and diastolic BP and chronic effects using aerobic training (8 weeks; 4 times per week; 65% VO_2peak). The greater correlations observed by Liu *et al*. (2012) compared to our study represent a more consistent response between acute and chronic effects observed after aerobic training. In fact, the analysis of acute and chronic individual responses revealed an inconsistency in most subjects, in which acute decreases in BP were not followed by a chronic reduction in BP, which limited to propose a prediction equation to estimate the chronic BP reduction based on acute BP responses. This can be partly explained by the inclusion of hypertensive subjects that were using different types of drug therapy, which may have attenuated BP responses to RE.

After a single bout of RE and after the resistance training programme, some patients increased in BP. Adverse response to exercise, a condition defined as an exercise-induced change that worsens a risk factor, has been previously described and is known to affect approximately 10% of subjects (Bouchard *et al.*, 2012). An interesting result of this study is that the correlation also included subjects that increased BP with exercise training, suggesting that the acute bout of RE can indicate the subjects are more likely to present an adverse response to the exercise training. This is particularly true for diastolic BP, for which the acute and chronic effects of RE on BP were in the same direction in most of our subjects.

The practical application of this study is that changes in BP after a single bout of RE can help to predict the long-term responses to resistance training. Thereby, execution of only a single bout of exercise can help an exercise trainer to define the best exercise intervention for each hypertensive individual, potentiating the effects of training and minimizing the likelihood of an adverse response.

The present study had some limitations. Only hypertensive women were included, and results cannot be extrapolated for men. Subjects were generally taking multiple types of drugs to control BP, which does not allow an evaluation of the interaction between exercise and any specific class of medication. The risk of potential bias due to BP assessment is worsened by the fact that no control group was included in the experimental design. Usually, decreases in BP are acknowledged by comparison against an untrained control group (chronic effect) or, at least, a non-exercise control session (acute effects). Neither of these precautions was adopted in the methods to prevent bias in the obtained results. Finally, the acute response of BP was measured at just one point (60 min), which may very likely introduce assessment bias in the results. Moreover, we did not used ambulatory BP and HR monitoring during 24 h, which not allows us to analyse the ambulatory effects of RE in this population.

In conclusion, acute responses in BP after a single bout of RE were associated with chronic changes in BP after training programme. This finding makes the magnitude of changes in BP a promising candidate for the prediction of individual BP-related, which can contribute to resistance training prescription in hypertensive subjects. Further studies are required to elucidate the mechanisms linking the acute and chronic effects of resistance training on cardiovascular parameters.

Conflict of interest

The authors declare no conflict of interest.

References

Beneka A, Malliou P, Fatouros I, Jamurtas A, Gioftsidou A, Godolias G, Taxildaris K. Resistance training effects on muscular strength of elderly are related to intensity and gender. *J Sci Med Sport* (2005); **8**: 274–283.

Bouchard C, Blair SN, Church TS, Earnest CP, Hagberg JM, Hakkinen K, Jenkins NT, Karavirta L, Kraus WE, Leon AS, Rao DC, Sarzynski MA, Skinner JS, Slentz CA, Rankinen T. Adverse metabolic response to regular exercise: is it a rare or common occurrence? *PLoS One* (2012); **7**: e37887.

Bush JA, Kraemer WJ, Mastro AM, Triplett-McBride NT, Volek JS, Putukian M, Sebastianelli WJ, Knuttgen HG. Exercise and recovery responses of adrenal medullary neurohormones to heavy resistance exercise. *Med Sci Sports Exerc* (1999); **31**: 554–559.

Caserotti P, Aagaard P, Larsen JB, Puggaard L. Explosive heavy-resistance training in old and very old adults: changes in rapid muscle force, strength and power. *Scand J Med Sci Sports* (2008); **18**: 773–782.

Cornelissen VA, Smart NA. Exercise training for blood pressure: a systematic review and meta-analysis. *J Am Heart Assoc* (2013); **2**: e004473.

Cuckson AC, Reinders A, Shabeeh H, Shennan AH. Validation of the Microlife BP 3BTO-A oscillometric blood pressure monitoring device according to a modified British Hypertension Society protocol. *Blood Press Monit* (2002); **7**: 319–324.

Go AS, Mozaffarian D, Roger VL, Benjamin EJ, Berry JD, Blaha MJ, Dai S, Ford ES, Fox CS, Franco S, Fullerton HJ, Gillespie C, Hailpern SM, Heit JA, Howard VJ, Huffman MD, Judd SE, Kissela BM, Kittner SJ, Lackland DT, Lichtman JH, Lisabeth LD, Mackey RH, Magid DJ, Marcus GM, Marelli A, Matchar DB, McGuire DK, Mohler ER 3rd, Moy CS, Mussolino ME, Neumar RW, Nichol G, Pandey DK, Paynter NP, Reeves MJ, Sorlie PD, Stein J, Towfighi A, Turan TN, Virani SS, Wong ND, Woo D, Turner MB. Heart disease and stroke statistics–2014 update: a report from the American Heart Association. *Circulation* (2014); **129**: e28–e292.

Liu S, Goodman J, Nolan R, Lacombe S, Thomas SG. Blood pressure responses to acute and chronic exercise are related in prehypertension. *Med Sci Sports Exerc* (2012); **44**: 1644–1652.

Melo CM, Alencar Filho AC, Tinucci T, Mion D Jr, Forjaz CL. Postexercise hypotension induced by low-intensity resistance exercise in hypertensive women receiving captopril. *Blood Press Monit* (2006); **11**: 183–189.

Moraes MR, Bacurau RF, Simoes HG, Campbell CS, Pudo MA, Wasinski F, Pesquero JB, Wurtele M, Araujo RC. Effect of 12 weeks of resistance exercise on post-exercise hypotension in stage 1 hypertensive individuals. *J Hum Hypertens* (2012); **26**: 533–539.

Mota MR, de Oliveira RJ, Dutra MT, Pardono E, Terra DF, Lima RM, Simoes HG, da Silva FM. Acute and chronic effects of resistive exercise on blood pressure in hypertensive elderly women. *J Strength Cond Res* (2013a); **27**: 3475–3480.

Mota MR, Oliveira RJ, Terra DF, Pardono E, Dutra MT, de Almeida JA, Silva FM. Acute and chronic effects of resistance exercise on blood pressure in elderly women and the possible influence of ACE I/D polymorphism. *Int J Gen Med* (2013b); **6**: 581–587.

Pescatello LS, Franklin BA, Fagard R, Farquhar WB, Kelley GA, Ray CA. American College of Sports Medicine position stand. Exercise and hypertension. *Med Sci Sports Exerc* (2004); **36**: 533–553.

Queiroz AC, Rezk CC, Teixeira L, Tinucci T, Mion D, Forjaz CL. Gender influence on post-resistance exercise hypotension and hemodynamics. *Int J Sports Med* (2013); **34**: 939–944.

Rezk CC, Marrache RC, Tinucci T, Mion D Jr, Forjaz CL. Post-resistance exercise hypotension, hemodynamics, and heart rate variability: influence of exercise intensity. *Eur J Appl Physiol* (2006); **98**: 105–112.

Santana HA, Moreira SR, Neto WB, Silva CB, Sales MM, Oliveira VN, Asano RY, Espindola FS, Nobrega OT, Campbell CS, Simoes HG. 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.

Terra DF, Mota MR, Rabelo HT, Bezerra LM, Lima RM, Ribeiro AG, Vinhal PH, Dias RM, Silva FM. Reduction of arterial pressure and double product at rest after resistance exercise training in elderly hypertensive women. *Arq Bras Cardiol* (2008); **91**: 299–305.

Vega J, Bisognano JD. The prevalence, incidence, prognosis, and associated conditions of resistant hypertension. *Semin Nephrol* (2014); **34**: 247–256.

Verdijk LB, Gleeson BG, Jonkers RA, Meijer K, Savelberg HH, Dendale P, van Loon LJ. Skeletal muscle hypertrophy following resistance training is accompanied by a fiber type-specific increase in satellite cell content in elderly men. *J Gerontol A Biol Sci Med Sci* (2009); **64**: 332–339.