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THE FAMILIAL HISTORY OF HYPERTENSION INFLUENCES THE BLOOD PRESSURE RESPONSE TO THE RESISTANCE EXERCISE IN NORMOTENSIVE MEN

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ABSTRACT

Introduction: It is well known that familial or genetic heritage is closely associated to hypertension. Thus the present study aimed to investigate BP response to resistance exercise from young normotensive subjects with (WFHH) and without (WTFHH) familial history of hypertension (FHH). Material and Methods: Forty-nine healthy male, engaged in military service, were clinically examined. After anamneses volunteers were divided into two groups based on the FHH (mother and/or father). The groups were named: WFHH (n=22) and WTFHH (n=27). Volunteers performed three sets of 10 repetitions of unilateral knee extension at 50%, 75% and 100% of 10 repetition maximum (RM), with two-minute rest intervals between sets. Blood pressure measures were obtained at rest (PRE) and immediately after (POS) each exercise set. Result and Discussion: The results reveal that WFHH group exhibited greater SBP and PP response to resistance exercise at 50% of 10RM. These findings may indicate the presence of functional, and/or subclinical structural changes in young subjects with FHH, which are not clear at rest condition, but revealed during light resistance exercise.

Key words: hypertension, exercise, heredity, blood pressure, cardiovascular physiology

INFLUENCIA DEL HISTORIAL FAMILIAR DE HIPERTENSIÓN EN LA RESPUESTA DE PRESIÓN ARTERIAL, TRAS UN PROTOCOLO DE EJERCICIO DE RESISTENCIA, EN HOMBRES NORMOTENSOS

RESUMEN

Introducción: es bien sabido que el patrimonio familiar o genético está estrechamente asociado a la hipertensión. Por lo tanto, el presente estudio tuvo como objetivo investigar la respuesta de BP al ejercicio de resistencia de sujetos normotensos jóvenes con (WFHH) y sin (WTFHH) historia familiar de hipertensión (FHH). Material y métodos: Cuarenta y nueve hombres sanos, que participan en el servicio militar, fueron examinados clínicamente. Después de las anamnesas, los voluntarios se dividieron en dos grupos según la FHH (madre y / o padre). Los grupos fueron nombrados: WFHH (n = 22) y WTFHH (n = 27). Los voluntarios realizaron tres series de 10 repeticiones de extensión unilateral de rodilla al 50%, 75% y 100% de 10 repeticiones máximas (RM), con intervalos de descanso de dos minutos entre series. Las medidas de la presión arterial se obtuvieron en reposo (PRE) e inmediatamente después (POS) de cada ejercicio. Resultado y Discusión: Los resultados revelan que el grupo WFHH exhibió una mayor respuesta de PAS y PP al ejercicio de resistencia al 50% de 10RM. Estos hallazgos pueden indicar la presencia de cambios estructurales funcionales y / o subclínicos en sujetos jóvenes con FHH, que no son claros en el estado de reposo, pero que se revelan durante el ejercicio de resistencia a la luz.

Palabras clave: hipertensión, ejercicio, herencia, presión sanguínea, fisiología cardiovascular

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INTRODUCTION

It is well known that familial or genetic heritage is closely associated with hypertension (Al-Safi, Aboul-Enein, Aboul-Enein, & Manuel, 2006; Ehret & Caulfield, 2013; Goldstein, Shapiro, & Guthie, 2006; van der Sande et al., 2001). Previous studies have shown that individuals with a family history of hypertension (FHH) have to a four times greater risk of developing hypertension themselves than average (Corvol, Jeunemaitre, Charru, & Soubrier, 1992; Williams et al., 1993). This clear relationship between FHH and elevated blood pressure (BP) has been studied through ambulatory BP measures or observing abnormal acute BP responses to exercise (Kaur, Walia, Narula, & Kaur, 2015).

In fact, the identification of an exaggerated BP response to exercise is a useful way of screening or predicting cardiovascular outcomes, such as left ventricular, incident hypertension (Berger et al., 2015; Miyai et al., 2000, 2002; Thanassoulis et al., 2012), carotid atherosclerosis (Jae et al., 2006), in normotensive and apparently healthy men. Additionally, an exaggerated BP response to exercise is a stronger predictor of morbidity and mortality from myocardial infarction (Mundal et al., 1996), cerebrovascular events (Kurl et al., 2001), and other cardiovascular events (Schultz et al., 2013; Thanassoulis et al., 2012), than casual blood pressure.

The association between an exaggerated BP response to exercise and cardiovascular outcomes, such as hypertension, has been studied exclusively through aerobic and/or graded (i.e., incremental or progressive) exercises. The influence of FHH on acute BP responses to resistance exercise has not been investigated. This issue gains relevance as the American College of Sports Medicine (Haskell et al., 2007; Medicine., 2009) and American Heart Association (Pollock et al., 2000) strongly recommended the inclusion of resistance exercises in physical activity and rehabilitation routines, owing to its beneficial effects for skeletal muscle and cardiovascular systems.

Despite this, the interaction between FHH and BP response to resistance exercise have not been studied. Therefore, this study aimed to compare the acute BP responses to resistance exercise from young normotensive subjects with and without FHH.

METHOD

Participants

Forty-nine healthy male volunteers, engaged in military service, were clinically examined to confirm the absence of hypertension (BP >140/90 mm Hg) or cardiac disease. Additionally, these subjects indicated they were not currently taking any medications. After anamneses the volunteers were divided into two groups according to the familial history of hypertension (mother and/or father). The groups were named: With Family History of Hypertension (WFHH; n=22) and Without Family History of Hypertension (WTFHH; n=27). All procedures were approved by the local Ethics Committee according to the Declaration of Helsinki, and written informed consent was obtained from all participants included in the study.

Body composition measures

Height and body mass were recorded. Body mass index (BMI) was calculated as body mass (in kilograms) divided by the height (in meters, squared). Percentage of body fat and lean body mass was approximated using a three-site skin-fold method as proposed by American College of Sports Medicine (2000). A well-trained technician measured skin-folds three times at each site and the mean of the values was used.

Procedure

Ten repetition maximum (10RM) tests. In the week before the experiment, the load for 10RM (unilateral [self-reported dominant leg] knee extension) was determined for each subject in knee extension machine by using the maximum weight that could be lifted for 10 consecutive repetitions. If the subject did not accomplish 10RM in the first attempt, the weight was adjusted by 4-10 kg and a minimum of five minutes of rest was given before the next attempt. Only three trials were allowed per testing session. To increase the reliability of 10RM testing, the following strategies were employed: (a) the 10RM was measured on 2 nonconsecutive days that were separated by 72 hours, (b) exercise technique was monitored and corrected as needed, and (c) all subjects received verbal encouragement. The reliability of the 10RM loads was assessed with the intraclass correlation coefficient (ICC) and showed high reliability (ICC, r = 0.95).

Exercise protocol

A week after the last 10RM test, subjects performed a single acute session with three sets of 10 repetitions of unilateral (self-reported dominant leg) knee extension at 50% (first set), 75% (second set) and 100% (third set) of 10 RM, with two-minute rest intervals between sets. Subjects were instructed on proper breathing technique to avoid the occurrence of a Valsalva maneuver. To ensure that all subjects were moving at approximately the same velocity for each repetition, each set was timed using a metronome, which called out a cadence for the eccentric and concentric phases of each repetition. The repetition cadence consisted of a two-second eccentric phase followed by a two-second concentric phase.

Hemodynamics measures

Using standardized techniques [(Pickering et al., 2005)], a well-trained technician measured systolic and diastolic blood pressure by auscultation using a calibrated aneroid sphygmomanometer (BD®, Germany) and a stethoscope (BD®, Germany). Systolic blood pressure (SBP) was recorded as the moment of hearing the first Korotkoff sound and diastolic blood pressure (DBP) as the moment of disappearance of the last Korotkoff sound. SBP and DBP were measured before (i.e, at rest) and immediately after the end of each set of the exercise. The mean arterial pressure (MAP) was calculated using the formula: MAP = DBP + (SBP-DBP/3), and pulse pressure (PP) was calculated as a difference between SBP and DBP, for each blood pressure measure (i.e., before and after exercise set). All blood pressure measures were recorded with the volunteers seated in the knee extension machine. To avoid the inter-subject variability, the same well-trained technician performed all blood pressure measures.

Statistics

A 2x3 (2 groups x 3 intensities) ANOVA was used to compare normalized BP and PP response to exercise. Significant main effects were followed by appropriate post hoc tests with Bonferroni corrections. Statistical significance for all analyses was accepted at $p \le 0.05$ and the analyses were performed with the SPSS 21.0 (SPSS Inc., IBM, Chicago, IL, USA). Pre and post-exercise BP values are presented, but the normalized values (i.e., post-exercise BP/pre-exercise BP) were used to make comparisons between groups, and data are presented as mean±SE.

RESULTS

Table 1 displays the body composition and resting blood pressure of the subjects after separation according to Familial History of Hypertension group. There were no significant differences between groups in age and any of the body composition measures (height, body mass, percentage of body fat and lean body mass) ($p > 0.05$). None of the subjects enrolled in the study displayed hypertension (i.e., blood pressure ≥140/90 mmHg) at rest.

TABLE 1
Characteristics from groups. Mean±SD of age, height, body mass (BM), Percentage body fat (PBF), Lean Body Mass (LBM), resting blood pressure (Systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and pulse pressure (PP)) according to Familial History of Hypertension group. Familial History of Hypertension group (With (WFHH) and without (WTFHH) Familial History of Hypertension).

	Age (yrs)	Height (cm)	BM (Kg)	PBF (%)	LBM (Kg)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	PP (mmHg)
WTFHH	19±1	177±7	69±10	14±2	59±8	122±5	81±2	95±3	41±4
WFHH	19±1	176±5	66±7	13±4	57±5	120±5	80±3	94±3	40±5

ANOVA revealed normalized SBP and PP was significantly different between groups. As presented in Figure 1, WFHH group showed a greater rise in SBP (+12% *vs.* +8%; p=0.02) and PP (+32.5% *vs.* +18.7%, p=0.01) response to exercise at 50% of 10RM. No other differences between groups were noted.

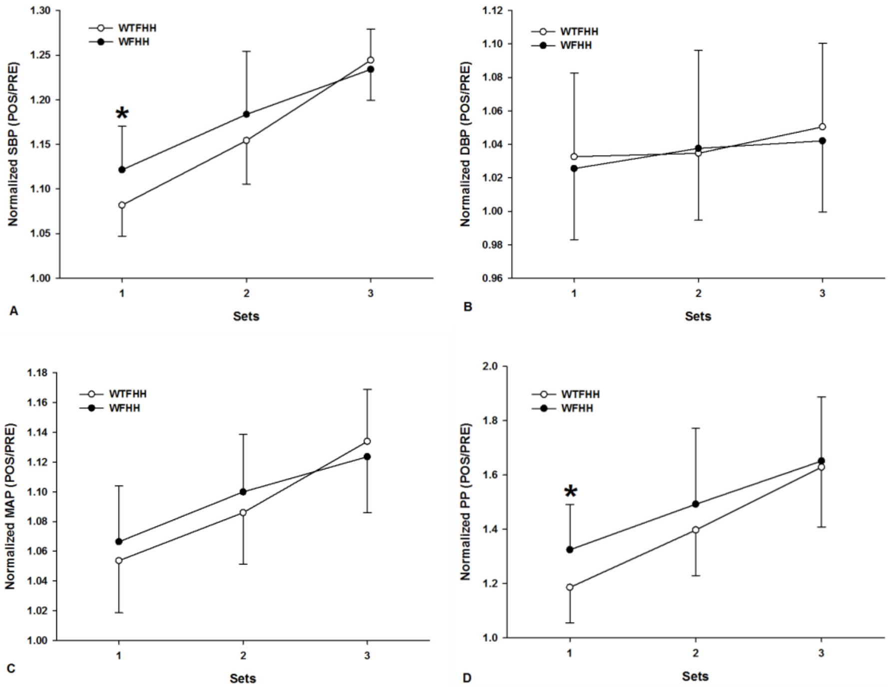

FIGURE 1: Mean±SD of normalized (post-exercise BP/pre-exercise BP) Systolic blood pressure (SBP) (A), diastolic blood pressure (DBP) (B), mean arterial pressure (MAP) (C) and pulse pressure (PP) (D) according to Familial History of Hypertension group (With (WFHH) and without (WTFHH) Familial History of Hypertension). The applied load was 50%, 75% and 100% of 10 RM for the first, second and third sets, respectively. (*) Significant difference between groups (p<0.05).

DISCUSSION

The goal of this study was to compare the BP response to resistance exercise in young normotensive subjects with and without FHH, and the results showed that the FHH is associated to greater SBP and PP response to resistance exercise, which was only evident at the lightest submaximal load (50% of 10 RM) examined. These findings may indicate the presence of functional, and/or subclinical structural changes that are not clear at rest condition, but reveled at light stressor conditions, as at resistance exercise.

The influence of FHH on SBP in resting conditions has been reported previously (Dekkers, Treiber, Kapuku, & Snieder, 2003; Goldstein et al., 2006). Dekkers et al. (2003) demonstrated a longitudinal increase of systolic blood pressure (SBP) in adolescents WFHH, but this trend was not investigated previously associated to resistance exercise. In the present study, resting BP between groups was similar, with a difference in BP only apparent immediately after light resistance exercise.

The precise physiological mechanisms explaining an abnormal blood pressure response to exercise are unknown (Schultz et al., 2013). Arterial stiffness and structural abnormalities in the peripheral vasculature are proposed mechanisms (Vlachopoulos, Aznaouridis, & Stefanadis, 2010). Additionally, elevations in serum cholesterol and insulin have been shown correlate with changes in BP with exercise (Brett, Ritter, & Chowienczyk, 2000). However, more work is needed to identify the precise underlying mechanisms.

Increases in BP during resistance exercise are well-documented (Lentini, McKelvie, McCartney, Tomlinson, & MacDougall, 1993; MacDougall et al., 1992), with SBP elevation attributable to greater vascular resistance as well as an increase in cardiac output. Since the FFH is a relevant risk factor for development of hypertension, and the pathophysiology of hypertension involves functional changes in the early phase of disease progress, followed by structural changes, culminating in clinical disease manifestation, it is plausible to hypothesize that normotensive subjects with FHH may present functional changes (N. Tzemos, Lim, & MacDonald, 2002), especially in peripheral vascular resistance, since endothelial dysfunction is observed in subjects with FHH (Taddei et al., 1996; Nikolaos Tzemos, Lim, Mackenzie, & MacDonald, 2015).

This hypothesis could explain why the SBP and PP differences between subjects with and without FHH were observed only at stressor conditions, as resistance exercise, and not observed in the resting condition. Early subclinical structural changes may not be discarded, since the group with FHH exhibited greater PP response to the resistance exercise. The PP is dependent on two major components related to the viscoelastic properties of large arteries: the ventricular ejection interacting with large arterial walls, a direct component, and the wave reflection, an indirect component. The rise in SBP and PP during exercise is mainly due to greater large-artery stiffness and an associated increase in wave reflection amplitude (Nichols, Nicolini, & Pepine, 1992; Nikolaos Tzemos et al., 2015).

Based on the differences in PP measured between groups in the present study, we speculate that normotensive young men with FHH could present greater large-artery stiffness than ones without FHH. The PP has been found to be useful in predicting risk for coronary heart disease (Franklin, Khan, Wong, Larson, & Levy, 1999). Future longitudinal studies may be able to reveal an association between the PP response to resistance exercises and cardiovascular outcomes.

Our results shed light on the relationship between of FHH and the BP response to resistance exercise, which may influence on the safety of exercise prescription and execution. It is important to note that significant differences between groups were observed only at low intensity (i.e., 50% of 10RM), but not at moderate and maximal exercise intensities (i.e., 75% and 100% of 10RM) resistance exercise, which may have importance for physical training and rehabilitation routines, and could pave the way for developing a predictive test to screen normotensive persons prone to develop hypertension. Further studies would be needed to confirm this hypothesis and find valid and reliable threshold values to predict future risks.

Wilson & Meyer (Wilson & Meyer, 1981) stated that an exaggerated BP response to exercise can provide a means for earlier identification of hypertension-prone persons. A recent meta-analysis identified that an exaggerated BP response to moderate exercise intensity, but not maximal exercise intensity, is an independent risk factor for cardiovascular events and mortality (Schultz et al., 2013). These authors hypothesized that difficulty obtaining blood pressure measurement during high intensity aerobic exercise might be one reason why submaximal BPs had a greater predictive value. Since BP measurements in response to resistance exercise are typically taken while subjects are not actively moving, there is no additional challenge to obtaining blood pressure, regardless of exercise intensity, thus resistance exercise my present an easier method to apply sufficient stress to reveal exaggerated BP responses. Further, assuming the current data can be replicated, the intensity of this resistance exercise stress required to reveal an abnormal response might be quite low (~50% 10RM), in contrast to graded exercise tests executed with treadmill or cycle ergometers. A single submaximal (i.e., 50% of 10RM of unilateral knee extension) resistance exercise set might be a suitable test to identify subjects with an abnormal blood pressure response to exercise.

This potential exercise protocol may demand a low cost and technical support, as well as a low work demand from the testing subject, which is especially important if the protocol is implemented on persons with cardiovascular diseases or physical limitations. Absolute hemodynamic responses (heart rate, systolic blood pressure, ejection fraction, cardiac output, LV end diastolic volume) are typically higher during treadmill testing than during strength testing or RT (at least up to 15 repetitions at up to 60% of 1-RM) for subjects with cardiovascular disease, as heart failure (Braith & Beck, 2008), thus, if workable, a resistance exercise test for abnormal blood pressure responses could be advantageous for patients with risk factors or symptoms of cardiovascular disease.

Physical trainers, coaches, physicians and physical therapists should consider the FHH when prescribing resistance exercises. Additionally, further studies could expand our findings, comparing the BP response to exercise from subjects WFHH and WTFHH during different resistance exercise routines, as well as modifying the rest intervals between sets of resistance exercise, or comparing subjects with different cardiovascular diseases.

Conclusion

Summarily, we found that the young normotensive subjects with FHH present greater SBP and PP response to resistance exercise at submaximal loads (i.e., 50% of 10 RM), suggesting the presence of functional, and/or subclinical structural changes in the cardiovascular system, which are not apparent at rest, but revealed at stressor conditions, such as a single set of light resistance exercise.

The FHH and acute BP responses to graded exercises with treadmill or cycle ergometers are widely used to screen subjects with a greater risk of developing hypertension. The results of this experiment support further investigations using resistance exercise at submaximal loads for screening hypertension-prone subjects in longitudinal studies.

These findings may indicate the presence of functional, and/or subclinical structural changes in young subjects with FHH, which are not clear at rest condition, but revealed during light resistance exercise.

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