SEX DIFFERENCES IN CARDIAC AUTONOMIC MODULATION AND BAROREFLEX SENSITIVITY FOLLOWING DIFFERENTIAL EXERCISE TRAINING

A Thesis
by
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FOREWORD

The research detailed in this thesis will be submitted to the journal of *Clinical Autonomic Research*, an international peer-reviewed journal owned by Springer, a subsidiary of Springer-Verlag GmbH, and published by Dr. Dietrich Steinkopff Verlad. The thesis has been prepared according to the guidelines set forth by the Graduate School of Appalachian State University.

ABSTRACT

SEX DIFFERENCES IN CARDIAC AUTONOMIC MODULATION AND BAROREFLEX SENSITIVITY FOLLOWING DIFFERENTIAL EXERCISE TRAINING. (AUGUST 2011)

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Maintained balance between sympathetic and parasympathetic tone within the cardiac autonomic systems is a vital component of cardiovascular regulation. The alteration of baroreflex function can contribute to chronic parasympathetic withdrawal and subsequent sympathetic dominance that is often seen in the development and progression of cardiovascular diseases. Heart rate variability (HRV) and baroreflex sensitivity (BRS) are non-invasive clinical measures utilized to assess baroreflex control and cardiac autonomic modulation, respectively. Aerobic exercise (AE) training has been shown to increase HRV and BRS; however, little is known concerning the response of HRV or baroreflex function to resistance exercise (RE) training. The purpose of this study was to assess the potential sex differences of short-term aerobic training versus resistance training on HRV and BRS in a hypertensive population. A 2x2x2 design was utilized to analyze mode (resistance vs. aerobic) x time (pre- versus post-training) x sex (male versus female). Forty pre- to stage-1 essential hypertensives between the ages of 33 and 60 years old (20 men, 20 women) underwent either AE training [30 minutes of treadmill exercise, 3 days per week at 65% of peak oxygen consumption (VO_2 peak)] or RE training (3 sets of 10 repetitions for 9 major muscle groups, 3 days per week at 10 repetition maximum). Body mass index (BMI), body composition assessment, electrocardiogram (ECG) recordings, beat-to-beat blood pressure (BP), and heads up tilt tests were performed at baseline pre and post 4 week training period. An increase in BRS was seen in both sexes following AE training; however, RE training, showed decreases in BRS in males and no change in females. Following RE training decreases in HRV as indicated by the low frequency to high frequency (LF: HF) ratio were seen in males, and increases in HRV were observed within females. These data show that 4 weeks of moderate intensity aerobic training results in increases in BRS and HRV in both sexes. The decrease in BRS seen in males following 4 weeks of RE training may be related to an increase in arterial stiffness in hypertensive individuals.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The autonomic nervous system, comprised of the parasympathetic and sympathetic branches, is important to the regulation of cardiovascular controls such as blood pressure (BP) and heart rate (HR). It has been shown that autonomic dysregulation is of clinical importance in the manifestation of cardiovascular disease, such as hypertension [27]. Further, the baroreflex, which operates through the autonomic nervous system, is an important regulatory mechanism in the short-term control of BP and HR [2]. Arterial baroreceptors function as pressor receptors and are located in the carotid and aortic arches. This position lends to their ability for rapid detection and systemic regulatory response throughout the arterial tree via the autonomic nervous system [2]. It is well known that an increase in systemic arterial pressure increases parasympethic tone and decreases sympathetic activation resulting in decreased HR, myocardial contractility, peripheral vascular resistance, and venous return. A decrease in systemic arterial pressure results in deactivation of baroreceptors, increasing sympathetic dominance and vagal inhibition. This augmented sympathetic tone leads to increased HR, cardiac contractility, vascular resistance, and venous return [14]. Changes in baroreflex function are reflected in alterations in cardiovascular autonomic modulation. The alteration of baroreflex function can contribute to chronic parasympathetic withdrawal and subsequent sympathetic dominance that is often seen in the development and progression of cardiovascular diseases [17] .

Baroreflex sensitivity (BRS) and heart rate variability (HRV) are non-invasive clinical measures utilized to assess baroreflex control and cardiac autonomic modulation respectively [7] . HRV, which measures autonomic regulation and HR control [7], has been shown to be reduced in individuals with hypertension; conversely, sympathetic dominant markers have been shown to be over expressed in hypertensive patients [11, 12]. Further, BRS, which measures baroreflex vagal control, is also reduced in hypertensive subjects [9]. Declines in BRS and HRV have been associated with an increase in all-cause mortality and morbidity [16].

Aerobic exercise (AE) has been proven beneficial in the reduction of cardiovascular disease due to the training response which increases vagal tone, thereby reducing heart rate and vascular resistance inducing reductions in systolic blood pressure (SBP) and diastolic blood pressures (DBP;13]. These alterations in BP, due to AE training may also be associated with favorable changes in cardiovascular autonomic modulation as well [19]. It has been shown that AE training favorably alters cardiac modulation through increases in parasympathetic activity and a functional increase in lysing of the sympathetic outflow [5]. Our lab has shown that 4 weeks of AE training increases BRS, HRV, and survival rates among essential hypertensive and post-myocardial infarction patients [15, 30]. Currently, resistance exercise (RE) training is only recommended as a complement to AE training for individuals with hypertension [1]. However, favorable decreases in hemodynamics and increases in blood flow have been shown following a RE training program and without concomitant increases in sympathetic tone at rest [24]. However, there is a paucity of literature concerning baroreflex responses to RE in an unmedicated hypertensive population. The few studies that have been conducted employed a mixed-sex cohort; however, preliminary data from our laboratory indicate that sex differences exist in the cardiovascular responses to exercise training. Therefore, the purpose of this study was to assess the potential sex differences of short-term aerobic versus resistance training on resting HRV and BRS in an unmedicated hypertensive population. We hypothesized that short-term RE and AE training would favorably alter HRV and BRS in both sexes; however, RE would benefit females to a greater degree due to less desensitization of the baroreflex.

METHODS AND PROCEDURES

Subjects

Forty sedentary subjects between the ages of ages 33 and 60 years old (20 men, 20 women) were recruited through local community physicians and matched by total time past initial diagnoses of hypertension. Each participant had been diagnosed with pre- or stage-1 essential hypertension on several visits to a primary care physician. A health history questionnaire provided by each subject's physician identified each subject as having no history of diabetes, coronary heart disease, or kidney disease. All subjects were non-smokers and were not on any type of medication, including aspirin. All women enrolled in the study were post-menopausal (history of greater than 12 months of amenorrhoea) and were not under hormone replacement therapy. Each subject provided written consent and then was randomly assigned to a RE or AE training group.

Experimental Design

Each subject made three separate visits to the laboratory. Subjects were post-prandial (greater than 3 hours) and were asked to avoid caffeine consumption and exercise on the days of testing. During the first visit, body composition and maximal aerobic capacity testing were completed, and if an individual was assigned to the RT group, a 10 repetition maximum strength measurement was assessed for major muscle groups. During the second visit, subjects rested supine for 15 minutes in a dimly lit, temperature controlled room, immediately followed by electrocardiogram (ECG) and beat-to-beat BP recordings for a period of 10 minutes. Subjects were then tilted heads-up to assess changes in HRV and BRS from the supine position. Following pre-assessment, subjects were randomly assigned to either 4 weeks of AE or RE training, and each training session was supervised by an exercise physiologist. At the completion of the 4-week training program, each subject reported back to laboratory between 24-48 hours following the last exercise session where post-training measurements were repeated during the same time of day and in the same order as the pre-training measurements.

Anthropometrics and Body Composition Assessment

Weight was calculated using a Bod Pod scale measured to the nearest one-half kilogram while height was calculated using a stadiometer measured to the nearest one-half centimeter. Body mass index (BMI) was calculated as: weight (kg) / height^2 (m^2). BodPod whole body plethysmography was utilized to measure body composition (BodPod; Cosmed, Rome, Italy).

Maximal Aerobic Capacity

Subjects randomized to the aerobic exercise training group each completed a customized peak oxygen consumption (VO_2 peak) protocol on a treadmill. Briefly, subjects began walking at 3 miles per hour for two minutes. Intensity was then increased by adjusting the speed until the participant reached a comfortable pace. Once a comfortable speed was attained, 2.5% grade adjustments every three minutes were made. Ratings of perceived exertion (RPE) and HR (Polar Electro, Woodbury, NY, USA) were recorded every stage throughout testing. Expired gases were measured using a Quark b^2 breath-by-breath metabolic system (Cosmed, Rome, Italy). Maximal effort was attained when subjects met three of the following four critera: (i) no change in HR with a change in workload, (ii) a final

RPE score of 17 or greater on the Borg scale (scale from 6-20), (iii) a respiratory equivalent ratio (RER) >1.15 and/or (iv) a ‘plateau’ in oxygen uptake with an increase in workload (greater than 150 mL). VO_2 peak was assessed both pre- and post-training in the AE group.

10-Repetition Maximum Resistance Exercise

Participants randomized to the RE training group each completed a series of 10-repetition maximum (10-RM) tests. A brief warm-up was performed followed by an estimated load for each exercise (lat pull down, chest press, shoulder press, leg extension, leg curl, leg press, biceps curl, triceps extensions, and abdominal crunch) and each participant was instructed to perform no less than 8 and no more than 15 repetitions. If the subject achieved more or less than 10 repetitions, prediction tables were utilized to adjust weight in 5 pound increments until preferred load was reached. Post program testing was utilized in the RE group to measure the efficacy of the training protocol.

Exercise Training

Measurements attained from pre-program testing were utilized in the development of the subjects’ training protocol. AE training consisted of 30 minutes of treadmill exercise 3 days per week at 65% of their VO_2 peak. RE training consisted of exercises for nine major muscle groups (lat pull down, chest press, shoulder press, leg extension, leg curl, leg press, biceps curl, triceps extensions, and abdominal crunch). Each subject was instructed to complete 3 sets of 10 repetitions for each exercise 3 days per week. Life Fitness resistance machines (Schiller Park, IL, USA) were utilized for training. Both groups attended training sessions for four weeks and were instructed to refrain from participating in any exercise outside of their AE or RE training sessions.

Hemodynamic Monitoring

With subjects resting in supine position, beat-to-beat BP was assessed for a period of 10 minutes through finger plethysmography (Finometer; FMS, Amsterdam, the Netherlands). Averages of the last 3 minutes in each 10 minute recordings were used in the statistical analysis. The Finometer was also utilized to estimate brachial BP.

Signal Acquisition and Analysis

Beat-to-beat HR was recorded using a modified CM5 configuration (Biopac Systems, Santa Barbara, CA, USA). The ECG recoding was collected online at a sampling rate of 1000 Hz in real time. Data collected were stored off-line to be used for analysis. Off-line signal processing was conducted in 10 minute periods. Visual inspection of all data was performed to inspect for ectopic beats and artifact and linearly interpolated to provide for a continuous data stream. An established ECG QRS complex detection algorithm was used to detect HR peaks and to generate an ECG R-R interval time event series (WinCPRS; Absolute Aliens Oy, Turku, Finland). The data stream was resampled at 5 Hz and passed through a low-pass filter with a cutoff frequency of 0.5 Hz. In order to improve temporal resolution a maximum entropy method was used to analyze the power spectrum. Akaike’s information criterion was utilized to determine the optimum order of the autoregressive model. A model order of 16 was used when this method resulted in less than 16 to avoid shifting of spectral peaks.

Power was determined through measurement of the area under the peak of the power spectrum density curve. Three peaks resulted and their corresponding frequencies were defined as high frequency (HF) region (0.15-0.40 Hz) and is indicative of parasympathetic tone of the heart; low frequency (LF) region (0.04-.015 Hz) and is indicative of both sympathetic and parasympathetic branches of the cardiac autonomic nervous system; and very-low frequency (VLF) region, which was not utilized for the purposes of this study other than the normalization of LF and HF HRV. The relative value of each power component, reported in both absolute and normalized units, was used to represent a proportion of the total power (TP). TP was indicative of overall variability and a marker of vagal tone within the heart. The LF to HF power (LF: HF ratio) was calculated to indicate sympathovagal balance. Standards provided by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology were carried out in all data analyses [7].

Arterial BRS was determined through analysis of the R-R intervals and beat-to-beat systolic arterial pressure (SAP) measured by the finger arterial pressure waveform derived from the Finometer. Fluctuation in HR and SAP were derived from these data and the sequence technique determined BRS (WinCPRS, Absolute Aliens Oy, Turku, Finland). Up-up (upup) and down-down (downdown) sequences were determined over at least three consecutive beats for 4 milliseconds (ms) and 1 millimeters per unit of mercury (mmHg) respectively. Only sequences with correlations greater than or equal to 0.80 were accepted. Transfer function technique was utilized as well to determine BRS, using the SBP and R-R interval spectra in the LF band (0.04-0.14 Hz) with coherence above 0.5.

Treatment of the Data

All data were analyzed using SPSS version 18 (SPSS, Chicago, IL, USA). Data were analyzed using a 2 x 2 x 2 [mode (resistance vs. aerobic) x time (pre- vs. post-training) x sex (male vs. female)] ANOVA with repeated measures. In the case of a significant interaction, a Bonferroni post-hoc test was conducted to determine where the significant changes in dependent variables occurred. A priori significance was set at an alpha less than 0.05 and all data are reported as mean ± standard error of the mean (SEM). Normal distribution of the data was assessed with a Shapiro-Wilke test. Data that were not normally distributed were then log transformed (natural log-transformation) prior to statistical analysis.

The sample of 40 subjects for our study was based on a power calculation performed on the frequency and BRS means and standard deviations (*SD*) of previously collected data from our laboratory gathered under similar protocols. The STATA statistical software package was used (College Station, TX, USA) for these calculations to determine the number of subjects necessary to give us adequate statistical power at a p less than 0.05. All variables entered into the model achieved a power no less than .8 with a sample size of 40 participants.

RESULTS

Subjects

Subject descriptive characteristics are reported in Table 1. Men had significantly greater mass and stature when compared to women. Women had significantly greater percentage of body fat and were significantly older when compared to the male subject population (Table 1).

Haemodynamic Variables

No significant interactions existed in SBP or DBP between sexes or training modes. However, significant changes in SBP were observed pre- to post-training in both the male AE and RE groups. Significant changes in DBP were also observed after training in the male AE group (Table 2).

Baroreflex Variables

BRS data determined by the sequence method are presented in Figure 1. A significant time by mode interaction existed for downdown sequencing. The male RE group showed a significant decrease in BRS downdown sequence changes from pre- to post-training while both the male and female AE groups showed an increase in BRS downdown sequence changes from pre- to post-training ($p = 0.008$). Furthermore, a significant interaction between sexes exists in BRS downdown sequence changes within the RE group. While females within the RE group showed an increase in BRS as a result of training, males demonstrated a decrease BRS following training. No significant interactions existed in the upup sequence with training in either group.

Heart Rate Variability

Pre- and post- training data are found in Tables 3 and 4 for the AE and RE groups, respectively. No significant interactions exist in TP between sexes following either training mode. A trend towards significant time by mode interaction (*p* = 0.064) exists in HF yet a significant time by gender interaction (*p* = 0.034) exists in LF. The frequency data were not normally distributed following analysis; therefore, the data were natural log transformed. Normalization of the data revealed a significant time by mode by gender interaction in normalized high frequency (nHF). A significant decrease was observed in the RE training group. This decrease was greater in men than women as noted in Table 4. There was also a significant time by mode by gender interaction in normalized low frequency (nLF). A significant increase in nLF was observed in the RE training group as a whole. The males increase in nLF was significantly higher than the increase observed in the females. A significant time by gender interaction was found in the LF:HF ratio as noted in Figures 2 and 3.

Table 1. Subject Characteristics

Variable	RE males	AE males	RE females	AE females
Age (y)	44±1.76	46±2.07	54±2.92^{+}	54±2.21^{+}
Stature (cm)	177±1.79*	179±2.10*	160±2.97	162±2.24
Mass (kg) Pre	100±4.63*	97±5.43*	62±7.68	73±5.81
Mass (kg) Post	101±4.9*	97±5.75*	62±8.13	73±6.15
Body fat (%) Pre	30±2.23	27±2.66	36±3.59^{+}	38±2.71^{+}
Body fat (%) Post	29±2.27	27±2.66	34±3.76^{+}	37±2.84^{+}

All data reported as mean ± standard error (SE) for *n* = 40. Baseline values were taken at initial lab visit. Pre-training values were taken at second lab visit following a 4 week control period. Post-training values were taken between 24 and 48 hours after final exercise session.

*-Men had significantly higher values than women (*p* less than 0.05)

+-Women had significantly higher values than men *(p* less than 0.05)

RE resistance exercise; *AE* aerobic exercise; *Y* years; *cm* centimeters; *kg* kilograms; *%* percent body fat from total body mass

Table 2. Descriptive Characteristics

Variable	RE males	AE males	RE females	AE females
SBP(mmHg) Pre	132±3.77	136±4.62	140±5.33	147±4.62
SBP(mmHg) Post	126±3.92*	131±4.8*	138±5.54	146±4.8
DBP(mmHg) Pre	79±2.44	80±3.0	71±3.45	79±3.00
DBP(mmHg)Post	76±1.73	76±2.12*	69±2.44	78±2.12
Pre RHR (bpm)	71±3.2	75±3.7	57±5.3	69±4
Post RHR (bpm)	73±2.8	68±2.75	58±5.2	66±3.8

Values reported as mean ± standard error (SE) for *n* = 40.

*Denotes significance at *p* less than 0.05.

RE resistance exercise; *AE* aerobic exercise; *SBP* systolic blood pressure; *DBP* diastolic blood pressure; *RHR* resting heart rate; *pre* pre-training; *post* post-training; *mmHg* millimeters of mercury; *bpm* beats per minute.

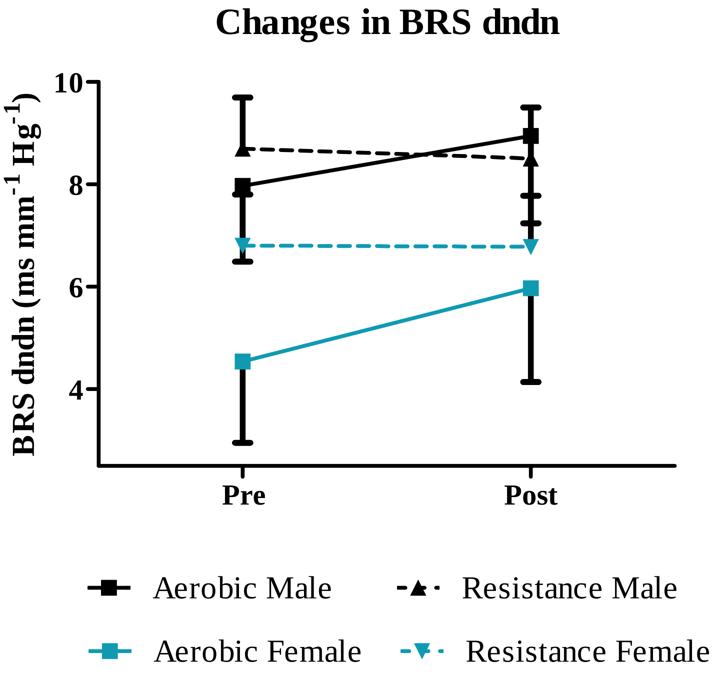

Figure 1.

Values reported as mean ± standard error (SE) for *n* = 40.

BRS dndn Baroreflex Sensitivity, utilizing down/down sequencing, changes from pre- to post-exercise training; *pre* pre-training; *post* post-training.

Table 3. Absolute Heart Rate Variability Measurements in the Aerobic Exercise Groups

Variable	Aerobic			
	Male		Female	
	Pre	Post	Pre	Post
TP (ms^2)	1586.88 ± 3093.58	1503.25 ± 1340.14	6931.88 ± 3093.58	3147.88 ± 1340.14
RMSSD	27.250 ± 7.784	29.250 ± 14.413*	19.286 ± 8.322*	30.714 ± 15.408
LF (ms^2)	822.5 ± 283.14	474.88 ± 234.56	114.14 ± 302.69	454.43 ± 250.76
HF (ms^2)	296.38 ± 163.95	514.13 ± 508.64*	239.57 ± 175.27	473.57 ± 543.76*
nLF	.706± .040	.558 ± .078*	.331 ± .057	.337 ± .083*
nHF	.271± .052	.410 ± .073*	.642 ± .056	.583 ± .078*

Values reported as mean ± standard error (SE) for *n* = 40.

*Denotes significance at *p* less than 0.05.

TP total power; *RMSSD* square root of the mean squared differences; *LF* low frequency; *HF* high frequency, *nLF* normalized low frequency; *nHF* normalized high frequency; ms^2 meters per second squared.

Table 4. Absolute Heart Rate Variability Measurements in the Resistance Exercise Groups

Variable	Resistance			
	Male		Female	
	Pre	Post	Pre	Post
TP (ms^2)	1896.75 ± 2525.90	2256.50 ± 1094.22	4143.17 ± 3572.16	4747.33 ± 1547.47
RMSSD	32.545 ± 6.638	38.636± 12.292*	65.000 ± 11.009	64.500 ± 20.383
LF (ms^2)	688.91 ± 241.47	633.91 ± 200.04	618.75 ± 400.43	1262.75 ± 331.72*
HF (ms^2)	422.27 ± 139.82	819.36 ± 433.77*	1293.5 ± 231.86	2072.0 ± 719.32*
nLF	.598 ± .046	.519± .066*	.322 ± .076	.584 ± .110*
nHF	.384± .044	.462 ± .062*	.662 ± .073	.402 ± .103*

Values reported as mean ± SE for *n* = 40.

*Denotes significance at *p* less than 0.05.

TP total power; *RMSSD* square root of the mean squared differences; *LF* low frequency; *HF* high frequency, *nLF* normalized low frequency; *nHF* normalized high frequency; ms^2 meters per second squared.

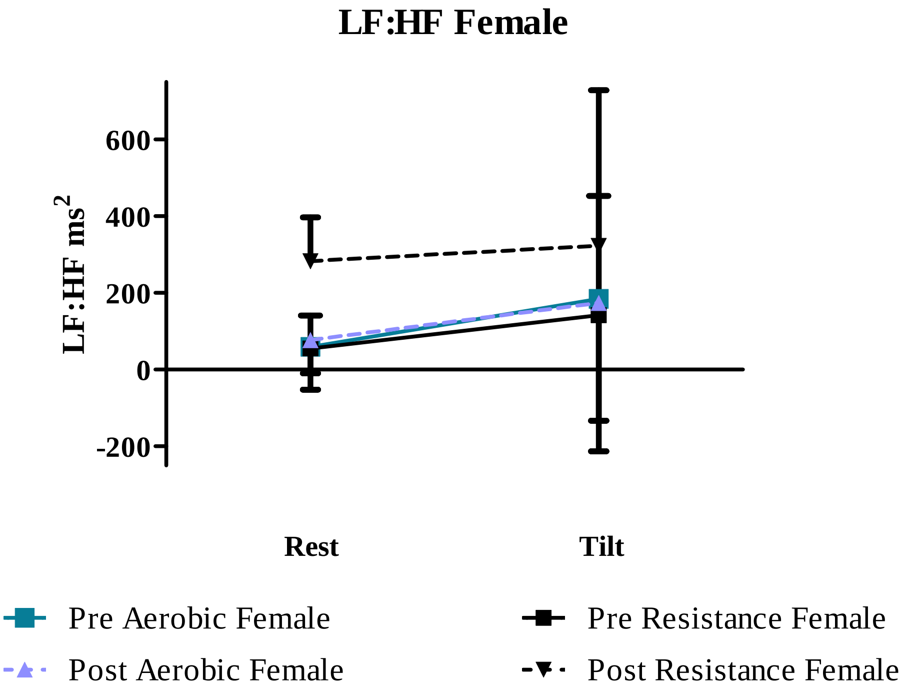

Figure 2.

Values reported as mean ± standard error (SE) for *n* = 20.

LF: HF low frequency to high frequency ratio changes in females at rest and at tilt; *Pre* pre-training, *post* post-training; *ms*^{2}meters per second squared.

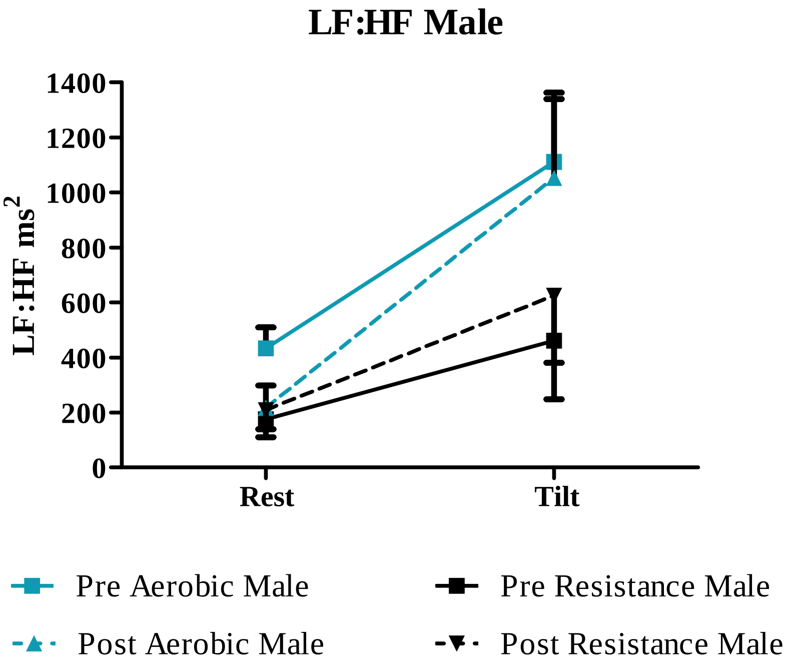

Figure 3.

Values reported as mean ± standard error (SE) for *n* = 20.

LF: HF low frequency to high frequency ratio changes in males at rest and at tilt; *Pre* pre-training, *post* post-training; *ms*^{2}meters per second squared.

DISCUSSION

Different cardiovascular autonomic and baroreflex changes are seen with 4 weeks of RE and AE training in males and females. The main finding of this study indicates that the decreases in BRS in males following RE training may be related to increases in arterial stiffness, therefore masking the pressor operating range in males; whereas, RE in females does not lead to decreases in BRS.

The baroreflex circuit detects changes in BP and activates responses in central autonomic outflow modifying HR and vascular resistance which results in homeostatic control of blood pressure [23]. However, in individuals with hypertension, BRS is diminished when compared with their normotensive counterparts [4, 29]. Individuals with hypertension demonstrate reduced parasympathetic and increased sympathetic cardiovascular drive resulting in an overall enhanced sympathetic modulation [22]. Studies have shown that HRV and BRS, measures of autonomic function, are higher in trained individuals when compared to their sedentary counterparts suggesting enhanced autonomic function [3, 18]. AE training has previously demonstrated reductions in SBP and DBP due to increases in BRS and HRV. Thus, survival rates among essential hypertensive and post-myocardial infarction patients have been shown to be increased following AE [15, 30]. The training effects of RE on autonomic function have not been extensively studied. Available literature does indicate that RE training results in beneficial changes in cardiac autonomic tone and decreased BRS [8]. However, precious literature suggests improved sympathovagal balance in patients with chronic heart failure (CHF) following 3 months of resistance training.

Baroreflex Sensitivity

No change in BRS exists as a result of AE training in either sex or in RE trained females, yet a decrease in BRS is resultant following RE training in males. These results are consistent with previous literature in normotensive subjects [10, 20, 28]. An enhanced BRS following just 3 weeks of AE training in hypertensive individuals has been attributed to reduced sympathetic outflow [21]. Our data paralleled these findings, as both AE groups increase BRS and decrease sympathovagal balance while the male RE group exhibits decreases BRS and increases in sympathovagal balance. Without a loss in BRS, the female cohort may realize less baroreflex sensitivity loss, which may be a factor contributing to an overall attenuation of arterial stiffness following RE when compared with their male counterparts. This study supports the fact that AE or RE exercise will decrease resting blood pressure in hypertensive adults; however, RE may be more favorable for women since they do not show decreases in BRS while their male counterparts do.

Heart Rate Variability

All groups indicated decreases in overall BP; however, only the RE groups showed changes in sympathovagal balance as indicated by the LF: HF ratio. The AE group showed no changes in either sex before or after training. The resistance training groups, however, showed different responses between the male and female groups. Decreases in sympathovagal balance were seen in the females as indicated by a decrease in the LF: HF ratio. Increases in sympathovagal balance in the males were noted by an increase in the LF: HF ratio. This suggests that females respond differently to RE when compared to males. Also, RE decreases in vagal tone and increases in sympathetic modulation were seen in males as a result of RE. Since decreases in BP were observed in all groups, these data suggest that alterations in BP following AE and RE training change through different mechanisms. Following 4 weeks of RE training females had a significantly greater increase in vagal withdrawal following tilt as indicated by significant changes in HF. Females showed greater decreases in vagal balance suggesting better BRS following RE training when compared to their male counterparts. Increased sympathetic modulation following RE is observed in women as indicated by the increase in LF after training. Interestingly, no change in men is shown in sympathetic modulation following tilt. Similar changes in LF values following tilt were observed in both sexes.

These outcomes parallel the results obtained with absolute or normalized data. While both sexes demonstrated loss in parasympathetic modulation following RE, females lost less of the HF component following training than men and less parasympathetic modulation following RE with tilt as indicated by the nHF values. These results are consistent with previous studies showing AE training increases vagal tone, leading to increases in HRV and decreases in resting HR [5, 25, 26]. RE training did show increases in vagal modulation during an autonomic challenge within the females as indicated by a lessened decrease in nHF following tilt when compared to the male RE group response. RE led to greater increases in nLF within males than females with tilt following training. These results suggest that while males and females respond differently to RE, females have more beneficial responses due to decreases in sympathetic tone and parasympathetic withdrawal during an autonomic challenge following 4 weeks of resistance training.

Beneficial changes in cardiovascular autonomic modulation were observed in the female groups and no change was shown in the male AE group. There is a paucity of literature in this area; however, one study showed no changes in HR or sympathetic tone in young normotensives following resistance training despite decreases in BP [6]. Our results are similar in that although males showed an increased sympathetic tone as a response to RE training with a concomitant decrease in the female cohort, both sexes showed decreases in BP. Our study is dissimilar to a recent study by Selig et al. whose lab showed improvements in cardiac autonomic function demonstrated by reductions in LF and LF: HF and increases in HF as a result of resistance training. However, this study population used individuals with chronic heart failure which have been shown to have compromised exercise capacities and any metabolic increases led to favorable HRV changes [26].

In conclusion, this investigation shows that AE is a beneficial intervention in the treatment of hypertension in both sexes. This is evidenced by the decrease in sympathetic outflow and increase in vagal tone as a result of training. Furthermore, RE training may be a favorable complement to AE training in female hypertensives. Exercise is an effective intervention in the treatment of hypertension. It is important to understand the mechanisms behind this treatment in both sexes in order to develop the most appropriate exercise prescription for male and female hypertensive patients.

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VITA

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