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Free-weight resistance exercise on pulse wave reflection and arterial stiffness between sexes in young, resistance-trained adults

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Abstract
We sought to determine the sex-specific effects of an acute bout of free-weight resistance exercise (RE) on pulse wave reflection (aortic blood pressures, augmentation index (AIx), AIx at 75 bpm (AIx@75), augmentation pressure (AP), time of the reflected wave (Tr), subendocardial viability ratio (SEVR)), and aortic arterial stiffness in resistance-trained individuals. Resistance-trained men (n = 14) and women (n = 12) volunteered to participate in the study. Measurements were taken in the supine position at rest, and 10 minutes after 3 sets of 10 repetitions at 75% 1-repetition maximum on the squat, bench press, and deadlift. A 2 × 2 × 2 ANOVA was used to analyse the effects of sex (men, women) across condition (RE, control) and time (rest, recovery). There were no differences between sexes across conditions and time. There was no effect of the RE on brachial or aortic blood pressures. There were significant condition × time interactions for AIx (rest: 12.1 ± 7.9%; recovery: 19.9 ± 10.5%, p = .003), AIx@75 (rest: 5.3 ± 7.9%; recovery: 24.5 ± 14.3%, p = .0001), AP (rest: 4.9 ± 2.8 mmHg; recovery: 8.3 ± 6.0 mmHg, p = .004), and aortic arterial stiffness (rest: 5.3 ± 0.6 ms; recovery: 5.9 ± 0.7 ms, p = .02) with significant increases during recovery from the acute RE. There was also a significant condition × time for time of the reflected wave (rest: 150 ± 7 ms; recovery: 147 ± 9 ms, p = .02) and SEVR (rest: 147 ± 17%; recovery: 83 ± 24%, p = .0001) such that they were reduced during recovery from the acute RE compared to the control. These data suggest that an acute bout of RE increases AIx, AIx@75, and aortic arterial stiffness similarly between men and women without significantly altering aortic blood pressures.

Keywords: Strength exercise, augmentation index, subendocardial viability ratio

Highlights
- Acute resistance exercise does not increase brachial or aortic blood pressure in resistance-trained adults.
- Acute resistance exercise increases pulse wave reflection similarly between the sexes.
- Acute resistance exercise increases aortic arterial stiffness similarly between the sexes.

Introduction
Increases in pulse wave reflection [augmentation index (AIx), AIx normalized at 75 bpm (AIx@75), and wasted left ventricular (LV) pressure energy (ΔEw)] and aortic arterial stiffness are independent risk factors for cardiovascular disease (CVD) (Hashimoto, Nichols, O’Rourke, & Imai, 2008; Weber et al., 2004). Over the past decade, studies examining acute resistance exercise (RE) on the AIx, AIx@75, ΔEw, and aortic arterial stiffness have continued to emerge, but with mixed results. Specifically, acute RE at 75% 1-repetition maximum (1RM) using free-weights increased the AIx, the AIx@75, and ΔEw (Tai, Gerhart, Mayo, & Kingsley, 2016) in resistance-trained individuals. Whereas, while acute RE at 65% 1RM on 8 weight machine exercises resulted in no changes in the AIx, it increased the AIx@75 (Yoon et al., 2010). Similar findings are also reported for aortic arterial stiffness, with studies demonstrating significant increases after acute RE (Fahs, Heffernan, & Fernhall, 2009; Kingsley, Mayo, Tai, & Fennell, 2016), or no change (Heffernan, Jae, Edwards, Kelly, & Fernhall, 2007). Since different methodologies may account for the discrepancies amongst studies, it is important that similar
methodologies be used to better understand the effects of acute RE on the cardiovasculature.

There are physiological similarities, and differences, between sexes for cardiovascular control. Specifically, women have similar resting heart rates (HR) as men in the third decade of life; thereafter, HR is higher in women (Hayward & Kelly, 1997). Nevertheless, women have significantly lower brachial systolic blood pressure (BSBP) (Hayward & Kelly, 1997), aortic systolic BP (ASBP), and reduced aortic arterial stiffness compared to men at rest (Kim et al., 2014) which may be dependent on sex steroids, as by the sixth decade of life there are no differences. On the contrary, Kim et al. (2015) demonstrated higher values for the AIx in women compared to men at rest, possibly attributed to a smaller diameter of the aorta, a mismatch between aortic diameter and blood flow, or early reflection of the reflected wave due to a shorter aorta in women (Mitchell et al., 2008). Collectively, these physiological differences between sexes at rest may also result in varying responses after acute RE.

To date, most studies (Heffernan, Collier, Kelly, Jae, & Fernhall, 2007; Heffernan, Jae, Edwards, et al., 2007; Yoon et al., 2010) have examined the AIx, the AIx@75, and aortic arterial stiffness after acute RE using primarily men. Cortez-Cooper et al. (2005), a resistance training study, utilized young, healthy women and demonstrated increases in the AIx and aortic arterial stiffness (Cortez-Cooper et al., 2005). Currently, no studies have evaluated responses to acute RE in resistance-trained women and therefore none have evaluated sex-specific responses to acute RE. Therefore, baseline and acute responses in resistance-trained individuals may be very specific, due to a progressive increase in both the AIx (Cortez-Cooper et al., 2005; Tai et al., 2016) and aortic arterial stiffness (Cortez-Cooper et al., 2005; Kingsley et al., 2016) at rest, that may be also affected by the sex of the individual (Collier, 2008).

Therefore, the purpose of the present study was twofold. One, to examine sex-specific differences in pulse wave reflection and aortic arterial stiffness at rest between resistance-trained men and women. Two, to evaluate sex-specific differences in pulse wave reflection and aortic arterial stiffness after acute RE between resistance-trained men and women. We hypothesized that at rest, the women would have similar HR, lower BSBP and ASBP coupled with higher values for the AIx, AIx@75, ΔEw, as well as lower aortic arterial stiffness. In addition, we hypothesized that after acute RE both sexes would have no change in brachial or aortic BP, increased HR, AIx, AIx@75, ΔEw, and increased aortic arterial stiffness with these values being augmented in the resistance-trained men.

Methods

Participants

Twenty-six adults (14 men and 12 women; 18–30 years) volunteered to participate. All participants were recreationally resistance trained (more than 1 year using free-weight exercises a minimum of 3 days a week). Additionally, participants were excluded from the study if they had: a recent smoking history (<6 months), CVD, diabetes, musculoskeletal issues, taking supplements or medications impacting HR or BP, or a body mass index (BMI) > 30 kg/m². All women underwent testing during the follicular phase (Days 1–13) of their menstrual cycle, denoted by the start of their period. All participants signed an informed consent prior to the collection of any data. This project was approved by the Kent State University Institutional Review Board and conformed to the Declaration of Helsinki.

Study design

The first two days of testing, Days 1 and 2, were to determine and verify the maximal strength for three exercises, the squat, bench press, and deadlift, separated by 72 hours. The next two days of testing, Days 3 and 4, were completed in a randomized order and occurred after a minimum of 1 week, and no more than 10 days, after the verification of the 1RM at the same time of day (±1 h). Participants performed either acute RE or a quiet control (control; supine rest for 30 minutes). All data were collected in a supine position, following a 10-min supine rest, and 10 min after the respective condition (Figure 1). Data collection occurred between 8 am and noon to control for circadian rhythm. Participants arrived for testing having abstained from food for 3 hours, caffeine and alcohol for 12 hours, and strenuous exercise for 24 hours. Following the 10-min period in the supine position, participants had their brachial BP taken followed by pulse wave reflection and then aortic arterial stiffness at rest and during recovery from the experimental conditions.

Anthropometrics

Height and weight were measured using a stadiometer and a balance beam scale, respectively. Height was measured to the nearest .1 cm while weight was measured to the nearest .1 lb and converted to kg. BMI was then calculated and reported as kg/m². Body composition was assessed with 7-site skinfold analysis. The Brozek equation was used to determine body density (Frisard, Greenway, & Delany, 2005).
Maximal strength

Maximal strength was assessed using the 1RM. Each participant was asked to lift the maximal amount of weight possible through a full range of motion utilizing proper form and technique (squat, bench press, and deadlift) (Baechle, Earle, & Wathen, 2008). Two minutes of rest was given between attempts and exercises. Three certified specialists supervised all of the lifts, acting as spotters as needed. The greatest load lifted over the two days was used to prescribe the workload for the acute RE.

Pulse wave reflection

Brachial BP was recorded by an oscillometer (SphygmoCor Excel, Atcor Medical, Sydney, Australia). One minute after the initial reading, a second reading was taken with the two BPs averaged if differences were within 5 mmHg. If not, a third reading was taken. Aortic BP waveforms were then derived using a general transfer function via application tonometry of the carotid artery (SphygmoCor Excel, Atcor Medical, Sydney, Australia). The AIx, which is determined by the reservoir pressure (Davies et al., 2010), is measured as the augmentation pressure (AP = P2-P1) expressed as a percentage of aortic pulse pressure (APP). The transit time of the reflected wave (Tr) was defined as the round-trip travel time of the forward travelling wave to the periphery and back to the aorta (Nichols & Singh, 2002). Previous data have shown an inverse relationship between the AIx and HR, therefore the AIx was normalized to 75 bpm (AIx@75) (Wilkinson et al., 2002) by the software to weaken the dependence on HR. The subendocardial viability ratio (SEVR) estimates myocardial perfusion and is independently associated with cardiovascular events (Tsiaakis et al., 2012). The software calculates SEVR from the ratio of diastolic area under the curve (diastolic pressure–time index (DPTI)) to the systolic area under the curve (tension–time index (TTI)). The ΔEw is indicative of the work produced by the LV and the myocardial oxygen consumption in order to overcome the increased ASBP (Casey, Nichols, & Braith, 2008). It was calculated as $1.33 \times \text{AP} \times \text{ΔTr} \times \pi/4$, with 1.33 for the conversion of mmHg/s to dynes s/cm².

Aortic arterial stiffness

To determine aortic arterial stiffness, we utilized aortic pulse wave velocity (aPWV). In short, the distance from the site of carotid sampling to the femoral artery, as well as the carotid artery to the suprasternal notch were measured with the distance from the carotid artery to the suprasternal notch subtracted from the carotid-femoral segment length by the software. aPWV was calculated from the distance between measurement points, and the time delay between proximal and distal foot waveforms using the following equation: $aPWV = D/\Delta t$ in which $D$ is the distance (metres) and $\Delta t$ is the time interval (sec). Each measurement was made in duplicate with <.1 m/s difference between measurements, and then averaged. If the measurement was >.1 m/s, a third measurement was taken.

Acute bout of RE

The participants performed acute RE that consisted of 75% 1RM with 3 sets of 10 repetitions for the squat, bench press, and deadlift, with two minutes of rest between sets and exercises. One warm-up set at 50% 1RM consisting of no more than five repetitions was used prior to completing each lift. Some participants had a drop in weight on the third set. Therefore, total exercise volume (sets × repetitions × weight) was recorded for each participant.

Statistical analyses

Independent samples t-tests were utilized to determine sex differences for descriptive variables. A three-way mixed analysis of variance (a 2 × 2 × 2 ANOVA) was used to determine the effects of sex (men, women) across condition (acute RE, control) and time (rest, recovery) for HR, BSBP, brachial diastolic BP (BDBP), brachial pulse pressure (BPP), pulse wave reflection [ASBP, aortic diastolic BP (ADB), APP, AIx, AIx@75, AP, Tr, DPTI, TTI, SEVR, and ΔEw] as well as aortic arterial stiffness [aPWV]. Paired t-tests were used for all post hoc comparisons with a Benjamini–Hochberg correction factor to control for alpha inflation. Percent change scores from rest to recovery were calculated ($\Delta$ score = (resting – recovery/resting) × 100) and evaluated using a multivariate ANOVA. All analyses were completed by a researcher that was not blind to the

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experimental condition. Data are presented as mean ± standard deviation. Statistical significance was defined a priori as $p \leq .05$. All statistical analysis was performed using IBM SPSS 23.0 (IBM, Armonk, NY, USA). Based on our preliminary data using 8 resistance-trained individuals, we calculated a Cohen’s $d$ of 1.1, and 1.3 with a power of .80, and an alpha of .05 for the variables AIx@75 and aPWV, estimating 11 participants per group.

**Results**

Participant characteristics for both sexes are presented in Table I. The sexes were similar ($p > .05$) for age, years of training, and fat mass. However, height ($p = .002$), weight ($p = .002$), and lean mass ($p = .0001$) were significantly greater in the men, who also had significantly lower ($p = .002$) levels of percent body fat compared to the women. In addition, the men had significantly greater ($p = .0001$) maximal strength for the 1RM on the squat (men: 157 ± 29 kg; women: 91 ± 18 kg), bench press (men: 117 ± 22 kg; women: 52 ± 10 kg), and deadlift (men: 174 ± 21 kg; women: 100 ± 26 kg). Despite the differences in 1RM, the total exercise volume for the acute RE was similar ($p = .07$) between sexes (men: 6905 ± 3415 kg; women: 4526 ± 1802 kg).

**Cardiovascular hemodynamics**

HR and brachial BP are presented in Table II, with no statistical differences between sexes at rest or during recovery. The acute RE significantly increased HR ($F_1, 44 = 107.2, p = .0001$). There was a statistically significant ($p < .02$) ΔHR noted by a 56.4% increase in the men and a 38.8% increase in the women. The acute RE did not change BSBP ($p = .67$), BDBP ($p = .10$), or BPP ($p = .10$). However, there was a statistically ($p = .02$) different ΔBPP after the RE between the sexes (men: 14.5% increase; women: 23.4% increase).

**Pulse wave reflection**

Pulse wave reflection data are presented in Table III, with no differences between sexes at rest or during recovery. After acute RE, there were significant elevations in the AIx ($F_1, 44 = 10.3, p = .003$), AIx@75 ($F_1, 44 = 34.1, p = .0001$), AP ($F_1, 44 = 9.3, p = .004$), and TTI ($F_1, 44 = 86.7, p = .0001$) compared to rest and recovery after the control. There was a statistically significant ($p = .02$) ΔTTI between the sexes with an increase of 52.5% and 35.4% in the men versus women, respectively. There were significant interactions for Tr ($F_1, 44 = 6.4, p = .02$), DPTI ($F_1, 44 = 44.1, p = .0001$), and SEVR ($F_1, 44 = 86.1, p = .0001$) such that they were

| Table I. Participant characteristics for men ($n = 14$) and women ($n = 12$). |
|--------------------------------------|--------------------------------------|
|                                       | Men                                  | Women                               |
| Age, yrs                              | 23 ± 3                               | 23 ± 4                              |
| Training, yrs                         | 6 ± 4                                | 9 ± 2                               |
| Height, m                            | 1.8 ± 0.1*                           | 1.7 ± 0.1                           |
| Weight, kg                           | 86.9 ± 16.2*                         | 65.8 ± 11.9                         |
| BMI, kg/m²                           | 27.5 ± 2.1                           | 24.3 ± 4.7                          |
| Body fat, %                          | 14.6 ± 6.5*                          | 25.8 ± 9.3                          |
| Lean mass, kg                        | 72.9 ± 9.9*                          | 53.7 ± 6.3                          |
| Fat mass, kg                         | 13.1 ± 8.5                           | 18.5 ± 9.9                          |

Note: BMI: body mass index.

* $p \leq .05$, significantly different between sexes.

| Table II. Differences in heart rate and brachial blood pressure in men ($n = 14$) and women ($n = 12$) at rest and during recovery from acute RE or a control. |
|--------------------------------------|--------------------------------------|
|                                       | Control                            | Resistance exercise                  |
|                                       | Rest                               | Recovery                             | Rest                               | Recovery                             |
| HR (beats/min)                       |                                    |                                     |                                    |                                     |
| Men                                  | 58 ± 8                             | 54 ± 7                              | 55 ± 6                             | 86 ± 10†¥                           |
| Women                                | 65 ± 10                            | 64 ± 14                             | 67 ± 28                            | 93 ± 16†¥                           |
| BSBP (mmHg)                          |                                    |                                     |                                    |                                     |
| Men                                  | 116 ± 7                            | 120 ± 11                            | 120 ± 11                            | 131 ± 9                             |
| Women                                | 117 ± 7.2                          | 116 ± 6                            | 116 ± 7                            | 124 ± 10                           |
| BDBP (mmHg)                          |                                    |                                     |                                    |                                     |
| Men                                  | 65 ± 4                             | 67 ± 5                              | 65 ± 5                             | 68 ± 4                              |
| Women                                | 69 ± 7                            | 69 ± 7                             | 69 ± 7                             | 66 ± 7                             |
| BPP (mmHg)                           |                                    |                                     |                                    |                                     |
| Men                                  | 51 ± 6                             | 53 ± 8                              | 55 ± 10                            | 63 ± 8                              |
| Women                                | 48 ± 4                             | 47 ± 6                             | 47 ± 9                             | 58 ± 7                             |

Notes: HR: heart rate; BSBP: brachial systolic blood pressure; BDBP: brachial diastolic blood pressure; BPP: brachial pulse pressure.

† $p \leq .05$, significantly different from rest.

¥ $p \leq .05$, significantly different from control.
attenuated after the acute RE and compared to recovery after the control. There were no interactions or main effects for aortic BP or $\Delta E_w$ ($p = .47$).

**Aortic pulse wave velocity**

$aPWV$ is shown in Table III, with no significant differences at rest or during recovery between sexes. There was an interaction for $aPWV$ ($F_1, 44 = 6.4, p = .02$) as there was no change over time after the control, but there was an increase in $aPWV$ during recovery after acute RE in comparison with rest and during recovery after the control.

**Discussion**

The purpose of the present study was to assess sex-specific differences in HR, brachial and aortic BP, $AIx$, $AIx_{75}$, $\Delta E_w$, other measures of arterial wave reflection and aortic arterial stiffness at rest, and after acute RE in resistance-trained individuals. The findings of the present study are: (a) that resistance-trained men and women have similar brachial BP, measures of pulse wave reflection and aortic arterial stiffness at rest, and after acute RE in resistance-trained individuals.
SEVR, with no significant alterations in brachial or aortic BP.

In the present study, HR, brachial, and aortic BP were similar at rest between sexes, which is contradictory to previously published data (Hayward & Kelly, 1997). Hayward and Kelly (1997) demonstrated that young women (aged 26 yr) had similar resting HRs, lower BSBP, and lower ASBP compared to age-matched men (Hayward & Kelly, 1997), but they did not control for phases of the menstrual cycle. Usselman et al. (2013) reported that despite elevated sympathetic activity during the luteal phase of the menstrual cycle, there were no changes in BP (Usselman et al., 2013). However, other researchers have reported significantly lower BDBP during the luteal phase compared to the follicular phase (Minson, Halliwill, Young, & Joyner, 2000) despite increased sympathetic activity. Therefore, the determinate of BP between sexes may arise from differences in autonomic modulation but not necessarily increases in vascular resistance as premenopausal women have more vagal tone at rest compared to age-matched men (Robertson, 1999). Since our participants were resistance trained, it is plausible that differences between the sexes were diminished. However, since the present study focused on acute RE, and we did not test autonomic modulation, this is a speculation.

The present study also demonstrated no change in brachial BP when taken 10 min following acute RE. Differences in the literature regarding brachial BP after acute RE may stem from when the measurement was taken, as well as the exercise protocols utilized or exercise intensity (Halliwill, 2001; Rezk, Marrache, Tinucci, Mion, & Forjaz, 2006). Kingsley et al. (2016) reported no change in mean arterial pressure 10 min post-exercise in resistance-trained individuals (11 men, 5 women) using similar methods as the present study. DeVan et al. (2005) reported no change in BSBP in active adults (11 men, 5 women) after 9 RE machines using 8-12 repetitions at 50% 1RM for one set, and one set to failure at 75% 1RM (DeVan et al., 2005). Tai et al. (2016), using the same methodology as the present study, as well as resistance-trained individuals (12 men, 3 women), reported no statistical change in brachial or aortic BP. However, they did note an increase of 5 mmHg in BSBP which is different from the present study which demonstrated increases in BSBP of 11 mmHg in the men and an 8 mmHg increase in the women after acute RE. Interestingly, the women had a greater ΔBPP compared to the men in response to acute RE, which has not been reported in the literature. This highlights the role of intensity in regulating BP responses to acute RE, as increases in BP are coupled with increases in the AIx, and aortic arterial stiffness (Kotsis et al., 2011).

The present study demonstrated no differences in the AIx between sexes at rest, which is supported by other work (Hayward & Kelly, 1997). However, other researchers have shown differences in the AIx between sexes (London, Guerin, Pannier, Marchais, & Stimpel, 1995). It has been proposed that the primary explanation for sex-specific differences for the AIx may be due to women being shorter than men, which translates to a shorter aorta and thus an earlier return of the reflected wave, increasing aortic AP (London et al., 1995). However, in our study, the height differential was not a contributing factor so other factors may have contributed. Since both TR and aortic arterial stiffness were similar between the sexes at rest, it can be assumed that arterial reservoir pressure was also similar (Davies et al., 2010). Another discrepancy may be during which phase of the menstrual cycle that the data were collected. Neither Hayward and Kelly (1997) nor London et al. (1995) reported which phase of the menstrual cycle data were collected. While data have shown that the menstrual cycle affects aortic arterial stiffness (Madhura & Sandhya, 2014), this may not be true for the AIx and AIx@75 (Papaioannou et al., 2009).

The results of the present study exhibit that acute RE increases the AIx and the AIx@75 in young resistance-trained men and women, which is supported by previous research (Fahs et al., 2009; Yoon et al., 2010). These changes in AIx may also be related to changes in HR as it has been shown that HR and AIx have an inverse relationship (Wilkinson et al., 2000). Nevertheless, if HR and AIx were truly inverse then the AIx would have been more attenuated in the study by Tai et al. (2016), which noted significant increases of 5.5% in the AIx with a 58% increase in HR. However, Tai et al. (2016) did not normalize AIx to BPP. The non-normalized AIx in the present study (not reported) demonstrated increases of 1.1% for men and 1.2% for women. The normalized AIx was increased by 37% in the men, and by 77% in the women. While these are not statistically different, it is important to note that for ΔAIx in the women was more than double that of the men. We also reported a significant increase in ΔHR of 56.4% and 38.8% for men and women, respectively. In comparison to the work by Tai et al. (2016), it appears that ΔHR is similar. With only three women in the work by Tai et al. (2016), this is not surprising. In the present study, the finding of a lower ΔHR, and an increased ΔAIx for the women, highlights that the responses to acute RE may be different between the sexes. This discrepancy between the work by Tai et al. (2016), and the present might be due to the lower HR during recovery or some other contributing
factor. The $\Delta AIx@75$, 425%, reported by Tai et al. (2016) is similar to the $\Delta AIx@75$ for the men in the present study, but is 25% higher than the women, further highlighting a physiological difference between the sexes that merits investigating. Based on these data, increases in the AIx and $AIx@75$ may be attributed to early arrival of the reflected wave. Regardless, our data demonstrate significant increases in the AIx, and the $AIx@75$, suggesting increased cardiac stress. However, more data are needed to fully understand if these effects are harmful, and how they are different between the sexes.

Our data suggest that acute RE reduces subendocardial blood flow similarly between the sexes, suggesting an increased risk for a cardiovascular event (Tsiachris et al., 2012). Interestingly, the present study demonstrated increases for $\Delta TTI$ of 52.5% and 35.4% in the men versus women, respectively, which was different between the sexes. Hayward and Kelly (1997) reported no significant differences between sexes for SEVR in the third decade of life, which supports our findings. To our knowledge, our study is the first study to examine changes in DPTI, TTI, and SEVR after acute RE between the sexes. Based on our data, the change in SEVR was driven by decreases in DPTI (reduced coronary blood flow), mediated by increased HR, and TTI, for both sexes after acute RE. As noted, the women in the present study demonstrated a reduced for $\Delta HR$ compared to the men, thus a lower for $\Delta TTI$ in the women is not unexpected. Collectively, it is clear that there is a decrease in coronary blood flow after acute RE, further demonstrating a transient increase in cardiovascular risk.

The present study demonstrates that resistance-trained men and women have similar aortic arterial stiffness at rest and after acute RE. The similarities at rest in our study are supported by previous data (Collier et al., 2010; Kingsley et al., 2016; Yoon et al., 2010). Using ‘moderately active’ men, Collier et al. (2010) reported increases in $aPWV$ after 3 sets with the 10RM for 8 different exercises 40 and 60 minutes post-exercise. In addition, Yoon et al. (2010) reported an increase in $aPWV$ (2%) at 20 min post-exercise. In our previous study, we reported a significant increase in $aPWV$ 10 min after acute RE of 9.6%, using the same protocol as the present study but with primarily resistance-trained men (Kingsley et al., 2016). In the present study, we demonstrated $\Delta aPWV$ in men of 7.3%, and 9.8% in the women. However, increases in $aPWV$ after acute RE are not universal (Heffernan et al., 2006; Heffernan, Jae, Echols, Lepine, & Fernhall, 2007). Heffernan et al. (2007) using resistance-trained men who underwent 3 sets at the 10RM for 8 different exercises, reported no changes in $aPWV$ 20 min after acute RE. The differences between findings may be due to the muscle mass utilized, since protocols as ours with more muscle mass recruitment have higher aortic arterial stiffness than ones that utilize upper- or lower-body exercise exclusively.

The main limitation of the present study is that we just analysed the aftereffects of acute RE, so the effect of this transient effect after a resistance training period on the vasculature in resistance-trained individuals depending on the sex cannot be inferred and is speculative. It has been suggested that further studies are needed that analyse how these acute and chronic changes are altered by the sex of the participants.

Conclusion

Acute RE produced comparable increases in the AIx, the $AIx@75$, and aortic arterial stiffness in resistance-trained men and women, without significantly altering aortic blood pressures. However, it is also important to keep in mind that while we did not see significant differences between the sexes, for $\Delta HR$, for $\Delta BPP$, and for $\Delta TTI$ after the acute RE was different between the sexes. This demonstrates the need for more information examining sex-specific differences in resistance-trained individuals after acute RE. Collectively, these data suggest that acute resistance exercises may have a similar transient effect on the vasculature regardless of the sex of the resistance-trained individual. However, it is important to note that while these responses may appear to have a negative effect on the cardiovascularity, it only provides information 10 min after acute RE. These responses may represent an adaptive protection specific for those that are resistance trained, thereby increasing the need for more research on the long-term effects of resistance training on the vasculature.

Disclosure statement

No potential conflict of interest was reported by the authors.

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