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Effects of habitual exercise on blood pressure during aerobic and resistance exercise in older individuals

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Abstract Blood pressure increases transiently during exercise in proportion to exercise intensity as a response to the increased demand for blood flow to the muscles. However, in addition to exercise intensity, many factors, including age and arterial stiffness, affect blood pressure during exercise. Aerobic exercises such as walking and cycling and resistance exercises such as lifting objects and climbing stairs are part of daily life activities. Therefore, exaggerated blood pressure responses to exercise increase the risk of cardiovascular disease. In this paper, the effects of habitual exercise on blood pressure during aerobic and resistance exercise are reviewed.

Keywords: exercise blood pressure, exercise training, resistance exercise, aerobic exercise

Exaggerated blood pressure response to exercise

Blood pressure transiently increases during aerobic and resistance exercise in proportion to exercise intensity as a response to the increased demand for blood flow to the muscles. However, many other factors besides exercise intensity affect blood pressure during exercise. We previously explored factors affecting blood pressure during self-paced outdoor walking using a wrist-type blood pressure monitor. Systolic blood pressure (SBP) was higher during walking compared to the resting state, but the increase in SBP was greater at the 1 km mark than at the 2 and 3 km marks. In stepwise regression analysis, air temperature and body mass index (BMI), as well as resting SBP and walking pace, were identified as independent predictors of SBP during walking. In laboratory tests during which exercise intensity was strictly controlled according to the testing protocol, age was an important factor affecting SBP during exercise; subjects older than 70 years had higher SBP during cycling than subjects in their 60s. With regard to resistance exercise, age, sex, arterial stiffness, BMI, and use of antihypertensive medication, as well as resting SBP, were identified as independent predictors of SBP during exercise.

Aerobic exercises such as walking and cycling, and resistance exercises such as lifting objects, mopping, and climbing stairs are part of daily life activities. Therefore, an exaggerated blood pressure elevation during exercise would increase 24-h ambulatory blood pressure (Fig. 1). Indeed, SBP during cycling and resistance exercise was correlated with 24-h ambulatory SBP in our previous study (unpublished data). Since ambulatory blood pressure is an important risk factor for cardiovascular disease, exaggerated blood pressure responses to exercise with aging, increases in arterial stiffness, higher BMI, and other factors increase the risk of cardiovascular disease. A systematic review and meta-analysis demonstrated that the relative risk of cardiovascular events and mortality increases 4.0% per 10 mmHg increase in SBP during moderate intensity aerobic exercise. Regarding resistance exercise, Chaney and Eyman reported that SBP during a static hand grip exercise is associated with future essential hypertension. In addition, we previously reported that SBP during a dynamic leg press exercise is an independent predictor of arterial stiffness. Ischemic heart disease and stroke are major public health problems that resulted in 14.1 million deaths in 2012, according to the World Health Organization. It is important to explore lifestyle modifications that can decrease blood pressure during aerobic and resistance exercise.

Effects of habitual exercise on blood pressure during exercise

Previous studies have reported that 16 weeks of aerobic exercise training decreases SBP during treadmill exercise in hypertensive and borderline or mildly hypertensive men. Aerobic training improves vascular load (i.e., arterial stiffness and vascular conductance) and blunts sympathetic vasoconstriction during exercise (functional sympatholysis). It has also been reported that endurance-trained athletes and physically active men with autism spectrum disorder have lower arterial stiffness. These vascular changes after the training period possibly lower SBP during aerobic exercise. In addition, 16 weeks of resistance exercise training in healthy individuals aged...
70-80 years seems to reduce blood pressure during sub-maximal aerobic exercise\(^\text{21}\!\). On the other hand, the effects of habitual exercise on blood pressure during resistance exercise were equivalent. To the best of the author’s knowledge, only two previous studies have investigated the effects of habitual exercise on blood pressure during resistance exercise\(^\text{22,23}\!\). In these studies, exercise tests were performed at the same percentage of one repetition maximum (1RM) before and after the resistance-training period. However, 12 or 19 weeks of resistance training could not decrease SBP during resistance exercise at 50-100% 1RM.

It is unclear why resistance training did not lower SBP during resistance exercise in the previous studies\(^\text{22,23}\!\), but one possibility is the effect of the intensive training load on skeletal muscles. For example, resistance training on a regular basis increases arterial stiffness\(^\text{14,24}\!\), a determinant of blood pressure. We have reported that arterial stiffness is higher in strength-trained individuals\(^\text{18}\!\). Arterial stiffening in strength-trained individuals may be associated with higher levels of plasma endothelin-1, a vasoconstrictor peptide\(^\text{19}\!\). On the other hand, aerobic training, which does not require intense muscle contractions, decreases vascular load\(^\text{14,16}\!\) and increases functional sympatholysis\(^\text{17}\!\). Therefore, we investigated the effects of daily physical activity levels and aerobic training on SBP during resistance exercise in middle-aged and older individuals\(^\text{4}\!\). In our cross-sectional study, daily physical activity levels and maximal oxygen uptake were correlated with and independent predictors of SBP during an arm curl exercise at 20 and 40% 1RM\(^\text{4}\!\). In an intervention study, SBP during resistance exercise was lower after 6 weeks of aerobic training (walking) compared to before the training period and the control group\(^\text{5}\!\). These results suggest that habitual aerobic exercise decreases SBP during low-intensity resistance exercise.

Our findings\(^\text{4}\!\) may have some clinical implications. First, the subjects were normotensive; SBP at rest was not correlated with levels of daily physical activity and did not decrease after the training period. SBP during resistance exercise may be a more sensitive marker of the effects of habitual exercise than resting SBP. Second, SBP was measured during flexion and extension of the elbow at low intensity (i.e., 20 and 40% 1RM) because low intensity upper arm activities are part of daily life activities. The association between 24-h ambulatory SBP and the exercise SBP measured in our study\(^\text{4}\!\) may be more significant than the association between 24-h ambulatory SBP and SBP during high-intensity lower extremity resistance exercise in previous studies\(^\text{22,23}\!\). Finally, the exercise test was easy to administer. Only dumbbells, an arm curl bench, and a blood pressure monitor were needed. In addition, the exercise intensity was low, making clinical application easy.

**Mechanisms underlying the effects of habitual exercise**

One mechanism that might be responsible for decreases in SBP during exercise is increased functional sympatholysis. Sympathetic vasoconstriction during exercise is attenuated in contracting muscles by vascular endothelium-derived factors such as nitric oxide (NO). However,
vascular endothelial function decreases with aging, leading to decreased functional sympatholysis in older individuals with a sedentary lifestyle. For example, plasma concentrations of soluble lectin-like oxidized low-density lipoprotein receptor-1 (LOX-1) are correlated with age; upregulation of LOX-1 reduces NO availability. Indeed, plasma concentrations of soluble LOX-1 were correlated with arterial stiffness. However, aerobic training improves endothelial function and increases functional sympatholysis. In addition, Mortensen et al. reported that functional sympatholysis is preserved in physically active older individuals. In our preliminary study, plasma concentrations of NO end products (NOx) were inversely correlated with SBP during aerobic and resistance exercise (unpublished data). Vascular endothelial function related to NO production may be implicated in SBP during exercise via functional sympatholysis.

In our intervention study, decreases in arterial stiffness after 6 weeks of aerobic training were correlated with decreases in SBP during resistance exercise. Vascular endothelial function is a potent regulator of arterial stiffness. We previously reported that changes in arterial stiffness following dietary supplementation are correlated with changes in plasma NOx concentration. The association between arterial stiffness and SBP during exercise can be interpreted as a reflection of improved vascular endothelial function with aerobic training, which might decrease SBP during exercise via functional sympatholysis. It is also possible that a reduction in arterial stiffness directly decreases SBP during resistance exercise, because the contribution of arterial stiffness to arterial load increases during exercise.

Conclusions

The author and colleagues demonstrated that habitual aerobic exercise decreases SBP during low-intensity resistance exercise in middle-aged and older individuals using both cross-sectional and interventional approaches. It is important because exaggerated blood pressure responses to exercise are a risk factor for cardiovascular disease. With regard to SBP during aerobic exercise, previous studies have shown that aerobic training decreases SBP. Further studies are required to elucidate the mechanisms underlying decreases in SBP during resistance exercise with aerobic training and clinical implications of resistance exercise SBP for assessment of exercise training effects.

Conflict of Interests

The author declares that there is no conflict of interests regarding the publication of this article.

References

14) Collier SR, Kanaley JA, Carhart R Jr, Frechette V, Tobin

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