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Short communication

The acute effect of maximal aerobic and isometric exercise on arterial stiffness parameters in boys and men

Elizabeth C. Schroeder [a,*], Sushant M. Ranadive [b,1], Kevin S. Heffernan [b,2], Sae Young Jae [b,3], Bo Fernhall [b,4]

[a] Department of Kinesiology & Nutrition, University of Illinois at Chicago, Chicago, IL, United States
[b] Department of Kinesiology & Community Health, University of Illinois at Urbana-Champaign, Champaign, IL, United States

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Abstract *Purpose:* To evaluate whether the acute effects of aerobic or isometric exercise on arterial stiffness parameters differ between boys and men.
Methods: Fourteen boys (10 ± 2 years, BMI 17.8 ± 1.9 kg/m^2) and nine men (26 ± 3 years, BMI 24.4 ± 3.3 kg/m^2) completed maximal aerobic and isometric exercise testing. Blood pressure and arterial stiffness parameters [β-stiffness index, central pulse wave velocity (PWV)] were measured at rest, 5- and 20-min post-exercise.
Results: Systolic blood pressure (SBP) increased at 5 min and returned to resting values at 20 min in both groups for aerobic exercise (time $p < 0.01$). Men had a greater increase in SBP at 5 min post-isometric exercise than boys (interaction $p < 0.01$). Diastolic blood pressure was not different between groups for either exercise mode. At 5 min, aerobic exercise induced increases in β-stiffness index with greater increases seen in men (interaction $p < 0.01$). Isometric exercise resulted in opposite β-stiffness index responses; men increased whereas boys decreased (interaction $p < 0.05$). Boys had lower baseline PWV than men at all time points ($p < 0.01$) and PWV significantly increased in men at 5 min post-aerobic exercise ($p = 0.01$); this interaction approached significance ($p = 0.051$).

Abbreviations: BMI, body mass index; MVC, maximal voluntary contraction; PWV, pulse wave velocity; AC, arterial compliance; EP, elastic modulus; SBP, systolic blood pressure.

* Corresponding author. Integrative Physiology Laboratory, University of Illinois at Chicago, 1640 W. Roosevelt Road (MC 529), Chicago, IL 60608, United States.
E-mail address: eschro7@uic.edu (E.C. Schroeder).
[1] Department of Anesthesiology, Mayo Clinic, Rochester, MN, United States.
[2] Department of Exercise Science, Syracuse University, Syracuse, NY, United States.
[3] Department of Sport Science, University of Seoul, Seoul, South Korea.
[4] Department of Kinesiology & Nutrition, University of Illinois at Chicago, Chicago, IL, United States.

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Conclusion: Boys show a differential arterial stiffness response following both aerobic and isometric exercise in comparison to men, which may be attributable to the seemingly quicker SBP recovery seen in boys.

Background

Large artery distensibility decreases with age leading to an increase in arterial stiffness, which is an independent predictor of future cardiovascular events and mortality.[1] Arterial stiffness increases throughout childhood[2] but can be modulated by lifestyle factors as stiffness increases with obesity and hypertension and decreases with greater amounts of physical activity in children.[3] Additionally, fitness is associated with arterial stiffness in children[4] and adults with metabolic syndrome.[5] These factors lead one to believe that arterial health can by affected in childhood and potentially mitigated by exercise. Additionally, with age, maturation of the autonomic nervous system produces increases in sympathetic nervous system activity and reductions in parasympathetic nervous system input, which may also contribute to arterial stiffness.[6]

In adults, an acute bout of aerobic exercise has been shown to reduce arterial stiffness, whereas resistance exercise increases arterial stiffness.[7] Exercise may also provide a stimulus to unmask potential differences between populations that do not exist at rest.[8] While children have lower blood pressure responses to both aerobic[9] and isometric exercise,[10] which would likely influence changes in arterial stiffness following both exercise modes, little information is available. Thus, understanding the vascular responses to acute exercise can provide important information about vascular differences between healthy age groups. We hypothesize that boys will have a smaller reduction in arterial stiffness post-aerobic exercise and smaller increase in arterial stiffness post-resistance exercise compared to men, and that the boys would show a quicker recovery to baseline values post-exercise.

Aim

The aim of this study was to evaluate whether the acute effects of maximal aerobic or isometric exercise on arterial stiffness parameters differ between boys and men.

Methods

Twenty-three healthy and recreationally active males, fourteen boys (10 $\pm$ 2 years) and nine men (26 $\pm$ 3 years), were recruited for voluntary participation. The level of sexual maturation was not determined for the boys, but, no significant pubertal influences were expected based on their age. Written informed consent was obtained from all children's parents and all adult participants. This study was approved by the institutional review board at the University of Illinois at Urbana–Champaign.

On experimental days, participants reported to the lab having refrained from caffeine and a minimum 3-h fast. Body mass (kg) and height (cm) were measured and used to calculate body mass index (BMI) (kg/m^2).

The two visits were randomized but occurred at the same time of day. During visit one, participants performed a graded exercise test on a stationary cycle ergometer (Lode Excalibur Sport, Lode, Netherlands) to voluntary exhaustion to assess maximal aerobic capacity. Cycling began at 25 W and increased 25 W every 3 min until exhaustion. Heart rate was determined electronically by an ECG monitor. Maximal work rate attained was used as a measure of aerobic capacity.

During visit two, isometric testing of maximal muscular strength of the quadriceps was performed using a leg dynamometer (Biodex, Shirley, NY) to determine maximal voluntary contraction (MVC).[11] Following a 5-min rest, a 3-min isometric contraction at 30% MVC was performed. These two modes of exercise were chosen because they produce opposite responses in arterial stiffness in adults.[7]

Heart rate was measured via a three lead electrocardiogram. Brachial blood pressure was measured by standard auscultatory methods on the left arm. All physiologic variables and carotid measurements were determined in the supine position at rest, 5-, and 20-min post-exercise. Immediate post-exercise measurements were not obtained as 5-min was required to position each participant, whereas previous research suggests at 20-min after acute exercise, significant alterations occur in the vascular wall properties, hence our reasoning for including this time point.[12] Central pulse wave velocity (PWV) was assessed by sequentially recording pressure waveforms from the carotid and femoral arteries (SphygmoCor SCOR, PWV Medical, Sydney, Australia) using standard methods.[13] Carotid artery diameters were obtained via ultrasonography using a high frequency (5–13 MHz) linear array probe (Aloka Ultrasound 5500 System, Japan) and β-stiffness index was calculated.[14]

Findings are expressed as mean $\pm$ SD. Two-way repeated measures ANOVA (time * group) was used to compare boys and men. When the ANOVA yielded a significant result ($p < 0.05$), post-hoc comparisons were made using the Bonferroni correction for multiple comparisons. Data analysis was performed with SPSS software, version 22.0 (Chicago, IL).

Results

Mean height, body mass, and BMI values for boys were 143 $\pm$ 9 cm, 36.9 $\pm$ 7.4 kg, and 17.8 $\pm$ 1.9 kg/m^2,