Influence of aerobic fitness and hypertension on aortic stiffness throughout the adult age span

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Introduction

Stiffening of the large conduit arteries is known to result in a cascade of deleterious physiological consequences, including isolated systolic hypertension, elevated left ventricular afterload and impaired coronary reserve. As a result, large artery stiffening is now recognized as a potent risk factor for premature cardiovascular mortality and morbidity.[1] The rate of propagation of the systolic pressure or flow wave in the aorta (aortic wave velocity, AWV) is a commonly accepted measure of central arterial stiffness.

MR has proven itself to be an excellent modality for evaluating arterial wave velocity, particularly with the advent of recently developed methods featuring acquisition times as short as one cardiac cycle. The excellent reliability of such methods has facilitated the deployment of MR studies of AWV in clinical studies with meaningful numbers of participants.

In the present study, using our developed one-dimensional (1-D) MR AWV sequences,[2,3] we sought to establish the dependence of AWV on age, using a cross-sectional study design. Recruitment was targeted toward three groups that were anticipated to exhibit differential dependence of AWV on age, namely endurance athletes, sedentary normotensive adults and hypertensive adults. We hypothesized that these three cohorts would be statistically distinguishable from each other on the basis of their groupwise AWVs.

Methods

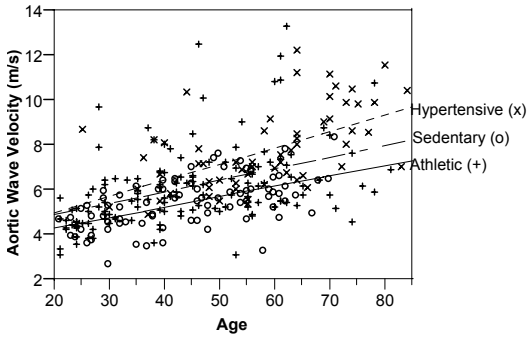
A total of 275 adults, representing a large age range (21 – 84 years) participated in this study. Women made up 46% of the sample. All participants underwent basic cardiovascular health screening, including blood lipid panel, fasting glucose, hsCRP and blood pressure measurements. A maximum cardiopulmonary exercise test on a treadmill with expired gas analysis was administered to determine peak oxygen consumption (VO_{2Max}) in ml/kg/min. A benchmark VO_{2Max} was also computed based on age, gender, height and weight. All prescription and non-prescription medications taken by subjects at the time of testing were recorded. Subjects on antihypertensive medication or whose average systolic blood pressure exceeded 140 mm Hg were assigned to the hypertensive category (N = 61). Normotensive subjects whose achieved VO_{2Max} exceeded their benchmark score by ≥8.0 ml/kg/min were assigned to the athletic category (N = 82), and all others (N = 132) were rated as sedentary.

Aortic wave velocities were measured using a 1.5T clinical MR scanner (Siemens Medical Solutions). All subjects underwent a minimum of five AWV determinations using a 1-D velocity method,[2] whereby the initial systolic flow waveforms were recorded at two axial sites within the descending thoracic aorta. In addition, 104 subjects also had their AWV assessed using a newer 1-D displacement method,[3] which employs a multifrequency RF tagging scheme. If the aorta was not straight within the measurement field, curvature correction was applied. Generally, the results of five individual trials were averaged to obtain the final AWV for a given method. We have found that agreement in terms of AWV is very good between the two methods, except among aged subjects, for whom the latter method excels.[4] Therefore, the displacement results, when available, were used for subjects 60 years and older.

The dependence of AWV on age was evaluated separately for the athletic, normotensive and hypertensive cohorts using linear regression. Significance of the differences between group mean AWVs was evaluated using a t-test and one way ANOVA.

Results

Figure 1 is a plot of AWV vs. age for all subjects; linear regression fits to the data are included for the three cohorts under study. While AWV was found to increase with age overall, relative to the healthy normotensive group, the athletic cohort exhibited reduced aortic stiffness (lower AWV), whereas the hypertensive group demonstrated accelerated aortic stiffness. A comparison of the group means (Fig. 2) reveals that AWV was significantly different among all three groups ($p < 0.0001$ at $\alpha = 0.05$).



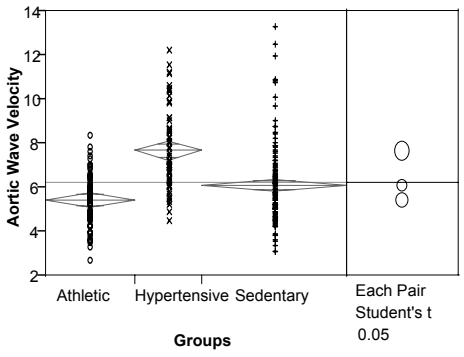


Figure 1 (Left): Linear regression fits of AWV as a function of age for three study groups. The equations are:
AWV (m/s) =3.49 + 0.073(Age)
AWV (m/s) =3.85 + 0.051(Age)
AWV (m/s) =3.37 + 0.046(Age) for the hypertensive, sedentary and athletic groups, respectively.

Figure 2 (Right): Groupwise variance analysis shows AWV means to be significantly different from one another.

Conclusion

Consistent with our hypothesis, these results show that among healthy adults, a higher degree of aerobic fitness across the age spectrum is associated with reduced aortic stiffness relative to a sedentary cohort. Conversely, subjects with or under treatment for systolic hypertension exhibit increased aortic stiffness compared to their normotensive counterparts. These results suggest that it may be possible to ameliorate cardiovascular risk using interventions that reduce premature aortic stiffening.

References

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