Influence of Lifestyle Modification on Arterial Stiffness and Wave Reflections

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Arterial stiffness and wave reflections exert a number of adverse effects on cardiovascular function and disease risk and are associated with a greater rate of mortality in patients with end-stage renal failure and essential hypertension. Accordingly, the prevention and treatment of arterial stiffness are of paramount importance. Because arterial stiffening is being recognized as a critical precursor of cardiovascular disease (CVD), it is essential to understand the role of lifestyle modifications on preventing and reversing arterial stiffening. Available evidence indicates that lifestyle modifications, in particular aerobic exercise and sodium restriction, appear to be clinically efficacious therapeutic interventions for preventing and treating arterial stiffening. Thus, sufficient evidence is available to recommend lifestyle modifications as part of a first-line therapeutic approach for arterial stiffening. However, more information is needed for a full understanding and optimal use of lifestyle modifications in the management of arterial stiffening. Am J Hypertens 2005;18: 137–144 © 2005 American Journal of Hypertension, Ltd.

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Large elastic arteries expand and recoil with cardiac pulsation and relaxation. During systole, a significant portion of the ejected stroke volume is stored by arterial distention, which acts to buffer the rise in systolic pressure and to convert pulsatile cardiac ejection into continuous blood flow in capillary beds. Reductions in arterial compliance and increases in arterial stiffness are believed to contribute to the pathophysiology of cardiovascular disease (CVD) and have recently been identified as powerful and independent risk factors for CVD.[1,2] Increased arterial stiffness can contribute to the development and progression of hypertension, left ventricular hypertrophy, myocardial infarction, and congestive heart failure.[1]

For most risk factors for CVD, the first-line approach for prevention and treatment for development of CVD is lifestyle modification (Fig. 1). Given the role of arterial stiffness as a critical precursor of CVD,[2] it is important to recognize the effects of lifestyle modifications for the prevention and treatment of arterial stiffening. An emerging body of evidence supports the concept that lifestyle modifications can prevent and reverse arterial stiffening. This article reviews the evidence regarding the influence of lifestyle modifications on arterial stiffening and wave reflections. The focus will be placed on increased physical activity, weight loss, a reduced salt intake, other dietary modifications, and smoking cessation. Much of the confusion in the field of arterial stiffness arises from the different terminologies and methodologies used to express the elastic properties of an artery.[3] In this review, we specified the methodology used in each study so that readers can assess each study with their own judgments. Interested readers may refer to a recent consensus report that reviewed various methodologies to assess arterial stiffness.[3]

Regular Exercise

Aerobic (Endurance) Exercise

A cross-sectional study from the Baltimore Longitudinal Study of Aging found that older men who performed endurance exercise on a regular basis demonstrated lower levels of aortic pulse wave velocity (PWV) and carotid augmentation index (AI; an indicator of the magnitude of arterial wave reflection and arterial stiffness) than did their sedentary peers.[4] We also reported that significant age-related increases in central arterial stiffness (aortic PWV and carotid augmentation index) were absent in physically active postmenopausal women and that aerobic fitness was strongly associated with arterial stiffness.[5] Physically active individuals often demonstrate resting bradycardia, which could act on wave reflections and pulse pressure

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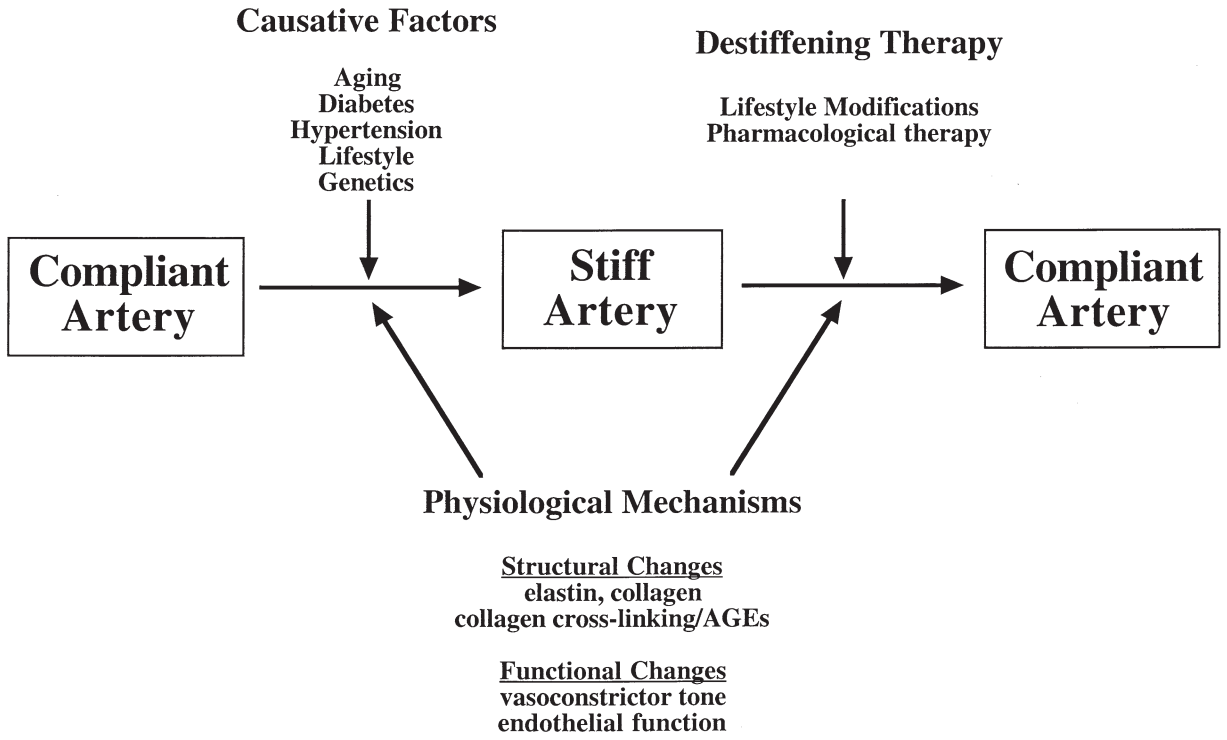

FIG. 1 Processes of arterial stiffening and destiffening. AGEs = advanced glycation end-products.

amplifications.[6] However, there are no consistent associations between resting heart rate and arterial stiffness in these studies involving endurance-trained adults.[5,7,8] In contrast to the effects on central elastic artery, peripheral arterial stiffness (leg PWV and arm PWV) was not different between sedentary and physically active adults.[5] These cross-sectional findings provide support for the role of regular aerobic exercise in the primary prevention of central arterial stiffening and wave reflections. However, athletic and sedentary adults may differ in terms of many constitutional factors. To demonstrate the direct effect of regular exercise on arterial stiffness, interventional studies are required.

Unknown to most, the first intervention study to determine the influence of exercise training on arterial stiffness was conducted in Japan. After 9 months of physical training incorporating a variety of exercises including jogging, soccer, handball, and judo, Ikegami et al[9] found a small but significant reduction in aortic PWV in 80 healthy young Japanese men. We recently completed an exercise intervention study involving previously sedentary but healthy middle-aged and older men, and reported that a relatively brief period (3 months) of aerobic exercise can increase carotid arterial compliance as measured with a simultaneous application of high-resolution ultrasound and applanation tonometry (Fig. 2).[8] This improvement was not associated with changes in body weight, adiposity, blood pressure (BP), plasma cholesterol, or resting heart rate, indicating a direct effect of exercise on arterial compliance. Importantly, this was accomplished with an intensity (moderate) and type (walking) of physical activity that can be performed by most, if not all, healthy older adults.[8] In contrast to central elastic arteries, the compliance of the peripheral muscular artery did not change with exercise training,[8] indicating that the effect of resistance training involves only central elastic arteries, which have a cushioning function that dampens fluctuations in pressure and flow. Because the effects of exercise training were observed only on the central elastic artery (carotid artery) but not on the peripheral muscular artery (ie, femoral artery), it is possible to hypothesize that some mechanical/physical (local) factors may have interacted with structural or functional mechanisms to improve arterial compliance. We recently prescribed an identical aerobic exercise program

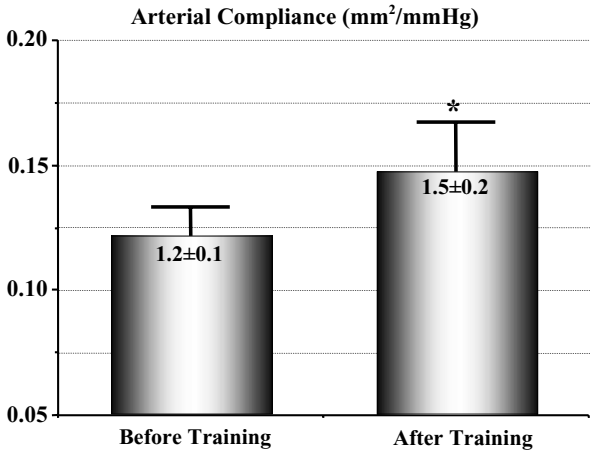

FIG. 2 Carotid arterial compliance before and after 3 months of aerobic exercise intervention.[8]