

Correlation of Health Span and Daily Body Postures from Blood Circulation Point of View

Nowadays, people spend a substantial amount of time per day on sedentary behaviors, and physical inactivity becomes the biggest public health problem of the 21st century.^[1,2] The years spent with poor health and disabilities in elderly age are also increasing. There is a drive to find strategies by which health span can be increased, optimal physiological function maintained, and the trajectory toward frailty lowered.^[3,4]

A general knowledge about the essential properties of an ideal ventricular-arterial (VA) system may help people reduce the harm arising from the new lifestyle. An ideal VA system is the one which meets the optimal power saving or highest efficiency for delivering blood from the heart to the ends of all the arterioles.

The pulsatile high-speed blood ejected from the left ventricle is similar to the alternating electric current generator. However, comparing with the electric power delivering system, an ideal VA system utilizes two extra power-saving methods. First, it may select a proper heart rate to enhance the efficiency of delivering blood to the arteries of the attached organs, head, and the four limbs by utilizing the resonance concept; this has been discussed previously. Second, unlike the electric power delivering system with the transmission line as the sole actor, the VA system has two actors, the blood and the elastic wall, to reduce the energy dissipation.^[5-13]

Arteries *in vivo* have a static internal pressure much higher than their surroundings, and subject to a strong longitudinal stretching ranged from 21% to 42%.^[14] Humphrey *et al.*^[15] concluded that axial wall stress is a fundamental contributor to arterial homeostasis, and it must be given increased attention both experimentally and theoretically. In the basal state, the arterial wall possesses a large circumferential elastic potential energy and a large longitudinal elastic potential energy since both of the circumferential and the longitudinal lengths are longer than their natural lengths, respectively.

As a high-speed blood bursts from the left ventricle in a short duration, it gives the aorta not only a pulse of blood but also a pulse of energy in the form of blood kinetic energy. If the aortic wall was stiff and its radius could not be extended, this energy would be greatly dissipated after the blood traveling a short distance. Since the aortic wall is highly distensible, the extra blood causes a further extension of the nearby aortic wall, induces the radial movement of the wall and the adherent blood, while the local pressure is also changed. Thus, most of the axial blood kinetic energy is converted to the elastic potential energy, and an impulsive force is acting on the wall to initiate its low damped oscillating in the radial direction. From

this instant, the aortic wall possesses most of the transferable energy and takes over the role of the first actor from the blood along the whole aorta. Only at the entry point of each attached branch will the blood temporally regain its role of initiator by bringing the pulsatile pressure and the pulsatile blood into the connected artery.

Since any power needs time to transport, the aortic radius and pressure of each small segments are not raising the same amount simultaneously along the aorta. This causes a radius gradient or a slope along the axial direction and therefore changes the longitudinal length or the longitudinal elastic potential energy of the local segments. Furthermore, due to the slope, the restoring longitudinal stress and the longitudinal tension have components in the radial direction which acting on the neighboring segments to initiate their radial movement and the accompanying variation of their circumferential elastic potential energy and the pressure of the enclosed blood. This power transmission process is very much like the stimulation of a transverse movement along a taut elastic string with large longitudinal tension. This procedure is also valid in all arteries with high elasticity.

It was found that almost all of the work done in distending the arteries is returned later in each cycle of the heartbeat, due to the relatively small viscosity of the vascular wall.^[14] Hence, the light-damped oscillation can travel along the aorta or along all large arteries with small attenuation. The superposition of all the responses initiated by the repeated blood input causes each segment of the arteries reaching a steady forced oscillatory state and manifests as a distributed steady pressure pulse after a short transient time.^[9] It is only until at the microcirculations, the wall becomes stiff and the blood is driven by the axial gradient of the pressure.

From these special characters of the VA system, we may thus conclude that keeping proper longitudinal stretching and cylindrical symmetry for all the elastic arterial walls are crucial for good blood circulation. In this state, the aorta and all large arteries can have proper distributed radial oscillatory motion, and the heart can beat at a stable rate that meets the optimal frequency matching rule.^[6,8]

Each moment of our life can be better cherished if we prepare our body well before starting any daily tasks. A better understanding of the operating mechanism of various mammal systems may help us to find rules to fine-tune our bodies. For example, in order to alleviate the burden on the heart, we may take a few seconds to check whether the head and the neck are up straight with right and left symmetry; the main aorta

acts as a one-dimensional string instrument by keeping its rotational symmetry and stretching the whole aorta properly; all organs are not under any abnormal bending to keep their own natural frequencies;^[5] the large arteries of the four limbs are properly stretching; and our hearts are calmed and beat regularly to meet the optimal frequency matching rule. In addition, when we walk, jog, or do rhythmic gymnastics or any repetitive exercises, maintaining the same pace as our own heartbeat is beneficial based on the frequency matching concept. Thus, not only the health span^[3] could be increased but also the sweetest music of each human being can also be performed; or as in Tagore's^[16] poem: "When all the strings of my life will be tuned, my Master, then every touch of thine will come out the music of love."

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