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Modulation of Common Carotid Arterial Function by Exercise: A Hemodynamics Study

Kairong Qin[1, *]

Abstract: Common carotid arteries (CCAs) are the major arteries supplying blood to the brain, and the hemodynamic variables in which are closely associated with the cardiovascular diseases. Exercise can induce the hemodynamic responses in the CCAs, including variations in blood pressure, circumferential stretch, and wall shear stress (WSS). Mechanosensors in the endothelial cells (ECs) are able to sense and distinguish these variations as mechanical signals, and transmit them into the interior of cells to affect cellular morphology and gene expression. Notably, reasonable exercises improve arterial structure and function, while unreasonable exercises cause endothelial dysfunction. Therefore, studies on the modulation of common carotid arterial structure and function by exercises are quite necessary, and it's significant to choose reasonable exercise modalities for improving arterial structure and function and preventing cardiovascular diseases. In this work, firstly, we studied the acute and chronic effects of different exercise modalities on the carotid arterial elasticity and hemodynamic variables. The results showed that the acute exercise caused the increases in arterial elastic modulus, blood pressure and the magnitude and frequency of WSS, and led to the decrease of arterial diameter; moreover, the changes in these hemodynamic variables exhibited an exercise-intensity-dependent manner. Additionally, the responses of intracellular nitric oxide (NO), reactive oxygen species (ROS) and the autophagy flux to WSS waveforms induced by different intensity exercise were also studied in a multi-component parallel-plate flow chamber system. The experimental results indicated that autophagy regulated intracellular NO and ROS production, and the magnitude and frequency of WSS induced by the moderate intensity exercise were more beneficial to improve arterial endothelial function than the high intensity exercise. Finally, the feasibility of quantitative regulation of the intracellular Ca^{2+} concentration in ECs by WSS was preliminarily investigated and confirmed in a microfluidic chip. In summary, our work indicated that it is feasible to choose reasonable exercise modalities to accurately modulate the hemodynamic variables, including blood pressure, blood flow and WSS in the CCAs, and then to improve the structure and function of the CCAs.

Keywords: Exercise, hemodynamics, common carotid arteries, structure and function, cell mechanobiology, parallel-plate flow chamber.

[1] School of Optoelectronic Engineering and Instrumentation Science, Dalian University of Technology, Dalian, 116024, China.

[*] Corresponding Author: Kairong Qin. Email: krqin@dlut.edu.cn.

Professor Kairong Qin (PhD), now is a Dean of School of Optoelectronic Engineering and Instrumentation Science in Dalian University of Technology, China. He got his BS degree in Mechanics and PhD degree in Fluid Mechanics from Fudan University in 1991 and 1996, respectively. After graduation, he became a lecturer and an associate professor in mechanical engineering in Fudan University until 2005. Meanwhile, he also conducted his postdoctoral training in Graduate School of Medicine, The University of Tokyo, Japan from 2002 to 2004. One year later, he became an associate professor in biomedical engineering in Shanghai Jiaotong University until 2007. He became a research fellow in National University of Singapore from 2007 to 2010. He moved to Dalian University of Technology as a full professor at 2010. His research interests include biomechanics, modeling and control in mechanobiology, microfluidics and biomedical instruments.