

Blood Flow Velocimetry for Health Care

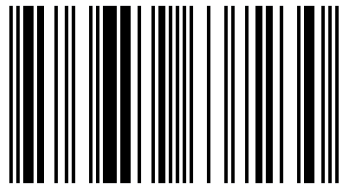
The purpose of this book is to provide a detailed explanation on the construction of a portable Doppler ultrasound system for medical application. It is hoped that researchers and the general public will benefit from reading this book to help them to better understand the basics and application of Doppler ultrasound system especially in the clinical setting. Included are data from several experiments involving the portable Doppler ultrasound system to analyse blood velocity in common carotid arteries in subjects with various medical and physical backgrounds. The focus is mainly on blood velocities in common carotid artery and how the information could be used to evaluate the risk of cardiovascular disease in hypertensive patients. The experiments include the association of regular exercise in improving blood velocities to manage the risk of hypertension and cardiovascular disease.

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# Portable Blood Flow Velocimetry for Health Care Monitoring

Epidemiological Investigations

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## Abstract

Doppler ultrasound instrument has been used in clinical setting for over 30 years and has served as a valuable method for the detection of arterial diseases. Several Doppler instrument designs and techniques have been proposed to provide quantitative measurements such as blood velocity, percent stenosis, and waveform indices. The ideal non-invasive method for detecting and quantifying atherosclerosis (formation of plaque inside the arteries) should be able to describe the level of disease over its entire spectrum, including configuration, function, composition and complication.

In this thesis, I present a detailed development of portable blood velocimetre system using Doppler ultrasound technique. The construction of the device is focused on miniaturisation of a Doppler discriminator circuit and a purpose-built ultrasonic probe, and the development of a stand-alone dialog software for signal monitor and analysis as described in Chapter 4. Prior to the construction of the device, it is important to understand the basic physics of Doppler ultrasound (Chapter 2) and to have basic understanding of particular blood flow in arteries (Chapter 3).

Of particular interest in the study is to assess health condition particularly in older people using information such as measurement of blood velocity in common carotid artery (CCA). Epidemiological investigation was performed on a total of 500 subjects to explore the association between blood velocity waveforms in CCA and other arterial haemodynamics, and the effects of age, gender, body size and so forth on blood velocity and its waveforms (Chapter 5).

From this investigation, it is found that physiological blood flow velocity in CCA is altered markedly with advancing age. (Reasons for changes in the velocity in older people?). However, it is unknown if regular aerobic exercise is able to improve blood flow velocity waveforms in either healthy young or healthy older individuals. (What is the importance/ significance of knowing this information?) We investigated the role of regular exercise on the age-associated alterations in blood velocity waveforms in CCA using cross-sectional and intervention approaches. First, we focused on 91 putatively healthy volunteers with age ranging from 20 to 76 years; 65 subjects were sedentary and 26 subjects were regular exercise-trained. We assessed the blood velocities at rest in peak systolic (S1), second systolic (S2), incisura between systole (I) and peak diastolic (D), and end-diastolic (d) in young, middle-aged and older subjects. Blood velocities in S1 were higher in exercise-trained, whereas S2, D and d were similar between exercise-trained and sedentary individuals. However, the indices of S1/S2 and D/I showed higher values in exercise-trained adults. Second, we studied seven young sedentary healthy subjects before and after one-month aerobic exercise intervention. The aerobic exercise increased whole velocity waveforms in CCA with association of decreased heart rate.

Gender-related differences in body size may affect the arterial haemodynamics such as systolic blood pressure, wave reflection and pressure wave propagation. (what makes you think gender related body size affects arterial haemodynamics?). To assess the possibility that the differences of carotid blood velocities and brachial blood pressure in both men and women are related to body size, we investigated the arterial haemodynamics in 50 healthy

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young adults (30 men, 20 women) between the age of 20 to 29 years old. Blood velocities are characterized into five components of velocity waveforms as peak systolic (S1), second systolic (S2), incisura between systole and diastole (I), peak diastolic (D) and end-diastolic velocity wave (d). According to our data, the most pronounced systolic blood pressure is lower in

young women than men ( $P<0.05$ ). Women have higher diastolic velocity components and second systolic velocity, but have lower systolic velocity compared to men. Thus, women have a significant wave reflection, smaller vascular resistive and lower vascular elastic recoil than in men. Greater body weight is associated with higher blood pressures ( $P<0.05$ ) and lower blood velocities ( $P<0.05$ ). Shorter body height affects not only the increased velocity wave reflection index ( $r=-0.519$ ,  $P<0.0001$ ), but also the decrease of peripheral vascular resistive index (RI) and arterial vascular elastic recoil index ( $r=0.463$ ,  $P<0.0001$ ;  $r=0.481$ ,  $P<0.0001$ , respectively).

In conclusion, our data suggest that regular exercise improves blood flow velocities in healthy young, middle-aged and older individuals and restores levels of what? after one-month exercise in previously sedentary young men. In addition, body size influences blood pressure and velocity regulations in young population (earlier you mentioned the test was for women). The findings are important in standardising the values of CCA blood velocities and its indices for the application of monitoring health.



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