Induced Local Thermal Hyperemia Coupled with Laser Doppler Flowmetry to Assess Endothelial Function

Biomedical Background and Motivation Endothelial dysfunction is one of the earliest markers in most cardiovascular diseases (CVD). Vascular endothelial cells line the entire circulatory system. A key indicator of a healthy endothelium is appropriate nitric oxide (NO) synthesis and release by vascular endothelial cells in response to a vasodilatory stimulus. Conversely, reductions in endothelial function are detrimental and precede the development of CVD. Currently, there are limited non-invasive methods that can assess endothelial function. Flow Mediated Dilation (FMD) is the most widely known non-invasive technique to measure endothelial function, but it is not well-adopted by clinicians due to the technical challenges of standardizing measurement of FMD and the relatively modest evidence of incremental change in risk assessment. Clinicians need standardized method of assessing endothelial health without the need to put patients through invasive procedures, especially when endothelial health information can be extracted using non-invasive optical methods. Laser Doppler Flowmetry uses the doppler phenomenon to detect changes in flow, typically used as a non-invasive measurement of microcirculation. Recent exploration of using Laser Doppler Flowmetry technology to measure changes in cutaneous microvascular blood flow in response to heat (vasodilatory stimulus) as an indicator of endothelial function has been promising, although further research is required before recommendation for clinical use.

The goal of this work is to develop and evaluate a non-invasive wearable device that will be able to measure changes in microvascular blood flow in response to heat, which can then be used to assess endothelial health. An effective wearable device successfully developed will empower clinicians to consistently and reliably assess endothelial function in patients to assess risk and employ intervention in advance of devastating clinical events such as myocardial infarction, stroke and other CVD.

Experimental design, methods, and analysis

To achieve this goal, Jaehah will help explore and evaluate various skin heaters to find the optimal heater that induces the expected vasodilatory response. Jaehah will also help optimize a method for precise temperature control for the skin heaters as achieving a local skin heating to $42°C$ is a critical requirement to induce cutaneous hyperemia. Once an optimal heater and temperature control method is determined, healthy individuals will be assessed using the selected heater coupled with a laser doppler flowmetry machine. In healthy individuals, the response to thermal hyperemia results in a distinct and predictable pattern, where an initial dilator response where skin blood perfusion (SkBF) peaks in a few minutes (usually within first 10 mins) is observed, followed by a postpeak drop in SkBF (termed the “nadir”), and a secondary dilation to a plateau (usually 20-30min post heating). Results will be analyzed to confirm chosen heaters and temperature control methods are effective. This work will help inform how to best incorporate these elements into a future wearable device designed for non-invasively assessing endothelial function.