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Assessment of Pulse Arrival Time for Arterial Stiffness Monitoring on Body Composition Scales

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Abstract

This study presents a system that aims to estimate changes in arterial health status in an unobtrusive way. It might be especially useful in long-term self-monitoring of cardiovascular performance for successful treatment and empowerment of patients. This system applies the electrocardiographic and impedance plethysmographic signals acquired using modified body composition scales for the calculation of pulse arrival time, which is directly related to arterial stiffness. The proposed device was tested in a cohort of 14 subjects. The modified scales were compared to the commercial PulsePen tonometer and the results showed significant relationship between these different devices ($r_s = 0.93$, $p < 0.01$). The system also showed the ability to track small pulse arrival time variations induced by paced respiration. These findings suggest that scales evaluating parameters of cardiovascular function have potential to become a convenient device for self-monitoring of arterial stiffness.

Keywords: unobtrusive long-term health monitoring, personal health technologies, multi-sensing device, impedance plethysmogram, slope sum function

1. Introduction

Stiffness of large arteries have a considerable impact on cardiovascular (CV) function. This mechanical property is responsible for maintaining continuous blood flow and retaining the shape of vessels under the high pressures. Therefore, changes in arterial stiffness can contribute to the development of CV diseases, and target organ, such as heart, kidney and brain, damage [1–4].

It has been shown that an abnormal aortic stiffness is independently associated with an increased number of CV events, as well as to all-cause mortality [5, 6]. This especially applies to elderly population [7–9], patients with end-stage renal disease [10, 11], impaired glucose tolerance [12] and hypertension [3, 4, 13]. In addition, an increased aortic stiffness is found to be associated with microvascular brain lesions [14]. Although most of studies have been dedicated to the investigation of aortic arterial stiffness, the impaired elastic properties of lower-limb arteries are also related to significant health issues, e.g., peripheral artery disease [15] and diabetic peripheral neuropathy [16].

Accordingly, periodic assessment of arterial stiffness has been suggested to be a part of long-term monitoring of target patients [2, 4, 5, 7–10, 12, 13]. Nevertheless, the technical concerns, notably, operator dependence and measurement standardization, restrict the inclusion of arterial stiffness characterizing parameters in clinical practice [17] and home-based monitoring. Therefore, a more convenient way for periodic estimation of arterial stiffness

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