



Asymmetric spread of heart rate variability

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ABSTRACT

Objective: The variability related to acceleration and deceleration of heart rate contributes unevenly to the overall heart rate variability (HRV). Thus, the spread of heart rate is asymmetric. Despite developing several heart rate asymmetry (HRA) measures, none examines this disparity in HRV. Therefore, a new HRA measure, asymmetric spread index (ASI), is proposed to measure asymmetry in the variability of heart rate associated with acceleration and deceleration. HRA generally arises due to cardiac autonomic modulation. However, the exact underlying phenomenon is unknown. Therefore, the study of HRA is performed in cardiac pathologies, synthetic HRV signals, and meditation.

Methods: Like other HRA measures, ASI is defined by using the Poincaré plot. The surrogate data analysis was performed to examine that ASI represents a physiological phenomenon and not an artifact of the method. Statistical analysis and receiver operating characteristic analysis were performed for evaluating the performance of HRA indices.

Results: HRA is found increased in patients with heart failure and arrhythmia. Synthetic HRV signals show less asymmetry than real HRV signals. The HRA increases during meditation. Experimental results indicate that variability shifts from the acceleration part to the deceleration part during meditation, and vice versa.

Conclusion: The ASI quantifies the uneven spread of heart rate that would remain unexplored with existing asymmetric measures. It shows better discriminating power than existing HRA.

Significance: Since HRA is a new area, further studies are required to establish its clinical significance. The ASI may help in understanding the underlying mechanism of HRA.

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1. Introduction

Heart rate variability (HRV) is a normal physiological phenomenon of variations in inter-beat intervals of the heart [1–3]. It is reported as a strong predictor of mortality due to cardiovascular causes [4]. The variations in heart rate during acceleration are not identical to variations during deceleration [5,6]. This imbalance introduces an asymmetry in heart rate popularly known as heart rate asymmetry (HRA). The HRA is a phenomenon of disparity in per beat acceleration and deceleration of heart rate. It provides additional information compared to traditional HRV analysis. Studies suggest that HRA represents autonomic modulation of the heart rate [6–8]. However, there is a lack of understanding regarding the exact underlying mechanism and require more attention and research.

Healthy heart oscillates in a complex dynamic pattern under the influence of autonomic nervous system (ANS) and other physiological processes, for instance, respiratory sinus rhythm, baroreceptor reflex, changes in vascular tone, etc. [1,3]. Two branches of the ANS, the sympathetic nervous system (SNS), and the parasympathetic nervous system (PNS), influence the heart rate in an opposite action. The SNS is known for speeding up the heart rate while PNS is known for slowing it down. These two opposite actions do not represent a “zero-sum” process. The influence of the SNS and PNS on heart rate is neither identical nor at the same speed. Indeed, their interrelationship is very complex [9]. Therefore, an imbalance is originated in the variability related to acceleration and deceleration [6].

HRA is get affected by a number of physiological and pathological conditions, for instance, mental stress [10,11], emotions [12], breathing pattern [13], PNS activity [14], ageing [15], type 1 diabetes [16], etc. It has been used for cardiac disease diagnosis [17,15,18]. It is suggested that the study of HRA, along with acceleration capacity and deceleration capacity, helps improve the prognosis and diagnosis of cardiovascular abnormalities [19]. HRA is present in healthy individuals, even in newborns as well as in fetal heart rate [20,21].

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