

Discrepancies between Implementations of Common HRV Metrics

Esko Toivonen, Teemu Pukkila, Esa Räsänen

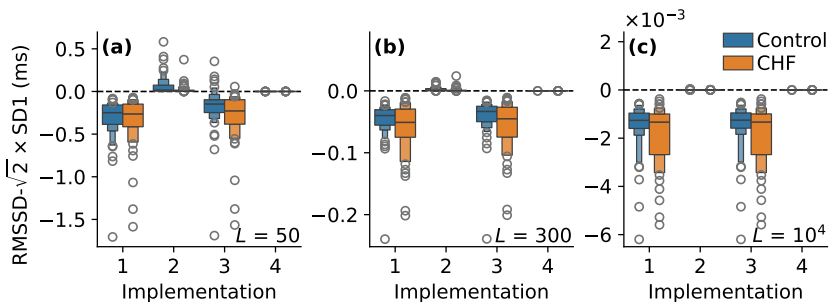
Computational Physics Laboratory, Tampere University, Finland

Background: The common HRV metrics, RMSSD and SD1 of the Poincaré plot, are generally considered mathematically equivalent, differing only by a constant scaling factor. However, there are discrepancies between results obtained from different open-source and proprietary implementations due to different assumptions that are not sufficiently addressed or discussed. Most importantly, SD1 calculations usually assume stationary differences of RR intervals, implying zero mean. However, this equivalence strictly holds only if the first and last interval of the time series are equal.

Methods: We analyze Holter ECG recordings from two groups: healthy controls (N=72) and CHF patients (N=44) from PhysioNet. We calculate RMSSD and SD1 values with different lengths of data L and with different implementations. We show that certain assumptions in the implementations are not fulfilled, resulting in different numeric values.

Results: In measurements with $L = 300$ RR intervals, corresponding to 5-minute rest segments, different implementations produce a difference of at most 0.25 ms. In more extreme cases, such as in 10-interval measurements, the difference can increase to over 10 ms in the worst cases.

Conclusions: Despite their supposed equivalence, the tested implementations yield different RMSSD and SD1 values that cannot be explained by rounding or floating-point inaccuracies. Care must be taken when implementing HRV calculations, especially in short segments. The primary concern is not the magnitude of the numerical difference but the lack of standards in the HRV field.



Boxplots showing how the measurement length L [(a) 50, (b) 300, (c) 10000] affects the difference between RMSSD and SD1. Implementations: 1: Kubios HRV Premium 3.5.0. 2: pyHRV, BioSPPy. 3: NeuroKit2, hrv-analysis, hrv. 4: Ciccone *et al.* (2017).