Structure of heart rate asymmetry: duration of monotonic runs

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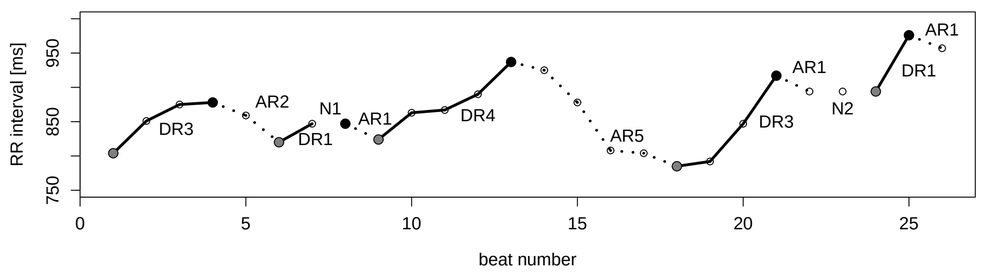
1 Introduction

Heart rate asymmetry (HRA) is the physiological phenomenon by which the contributions of accelerations and decelerations to the variability and structure of the RR-intervals time series is different. This phenomenon was first described for heart rate variability (HRV) by partitioning short- and long-term as well as total variability into parts contributed by decelerations and accelerations only. It turns out that the contributions of decelerations to short-term variability are bigger than those of acceleration, and this is reversed for long-term and total variability, i.e. the contributions of accelerations are grater than those of decelerations [1, 2].
Another approach to studying HRA is the monotonic runs method which analyses the structure of HRV. In this method the lengths and numbers of monotonic runs are studied. A *run* is an uninterrupted sequence of accelerations (*RR*-intervals which become shorter), which is preceded and followed by a deceleration (this is an *accelerations run* – AR) or an uninterrupted sequence of decelerations (*RR*-intervals which become longer), which is preceded and followed by an acceleration (this is a *decelerations run* – DR). Of course at the boundaries of the time series or after a beat of non-sinus origin the definition is modified so that they can be preceded or followed by a beat of non-sinus origin or beginning/end of the recording. For runs which consist of *RR*-intervals of the same lengths we define a *neutral run* [3, 4]. An illustration of the definition can be seen below.



By the *length* of a run we mean the *number of beats in a run*. It has been found that the acceleration runs are longer and more numerous than deceleration runs - runs of accelerations of all lengths, with the exception of lengths 3 and 4, are more numerous than those of decelerations. Also, the longest runs in 24-hour recordings are almost exclusively runs of accelerations [3]. The runs method has an independent predictive value in post-infarction patients [4]. For the precise definition of the above runs and other details see [3, 4].
Since heart rate must be kept within the physiologically realistic set of values, it is reasonable to expect that this mechanism should be compensated by a different distribution of the *duration* of the accelerations and decelerations runs. By *duration* of a run we mean the sum of all *RR* intervals in a run expressed in units of time. Such a compensatory mechanism can be observed in the variance-based HRA descriptors [5]. The aim of this study is to establish the distribution of durations of runs and check for the existence of the compensatory mechanism in runs lengths vs. runs durations.

2 Materials and Methods

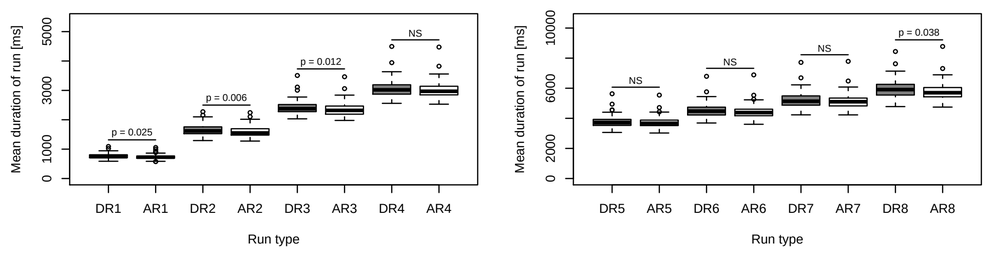
Eighty seven 24 hour ECG recordings were recorded in a group of healthy volunteers 25-41 years of age, 41 women. All of them reported to be healthy, were in sinus rhythm with resting heart rate 50-90 bpm, all had normal blood pressure, under 140/90 mmHg.
The runs analysis was carried out with in-house software written in python. Each RR intervals time series was partitioned into deceleration and acceleration runs. Runs of all lengths were counted separately for decelerations and accelerations. The obtained numbers of runs for successive runs lengths were compared between decelerations and accelerations with the nonparametric, paired Wilcoxon test. The durations of runs of corresponding lengths were compared with the one-sided unpaired Wilcoxon test. Unlike in the case of runs lengths analysis, only recordings in which specific runs were actually represented were used in the analysis.

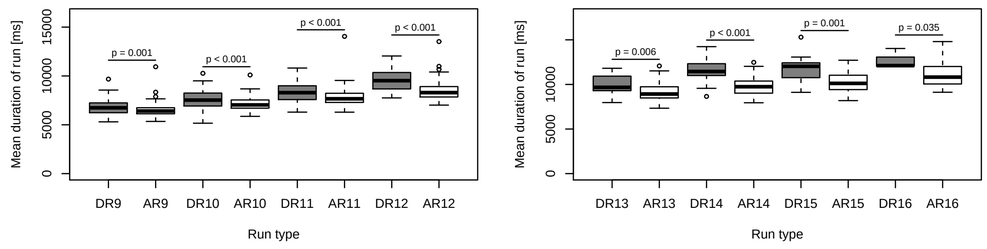
3 Results

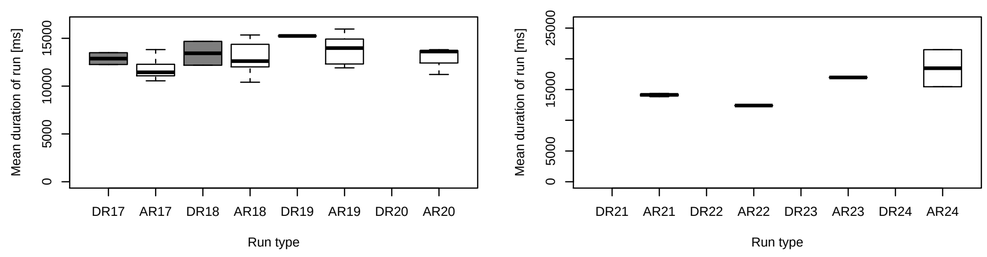
Below, we present the results for both: runs lengths distributions and comparisons between decelerating and accelerating runs as well as the distributions of runs duration with the same comparisons.

3.1 Runs length

Only the numbers of runs of length 3 and 4 were not significantly different for decelerations and accelerations. For all the other lengths there were significantly more runs of accelerations than decelerations. This phenomenon was especially visible for the longer runs. The longest run recorded in the group was an acceleration run of 24, the longest deceleration run was 19 beats long. Altogether, there were 1940 runs above length 10 and 7 runs above 20 for accelerations, the respective numbers for decelerations are 463 above length 10 and 0 above 20.

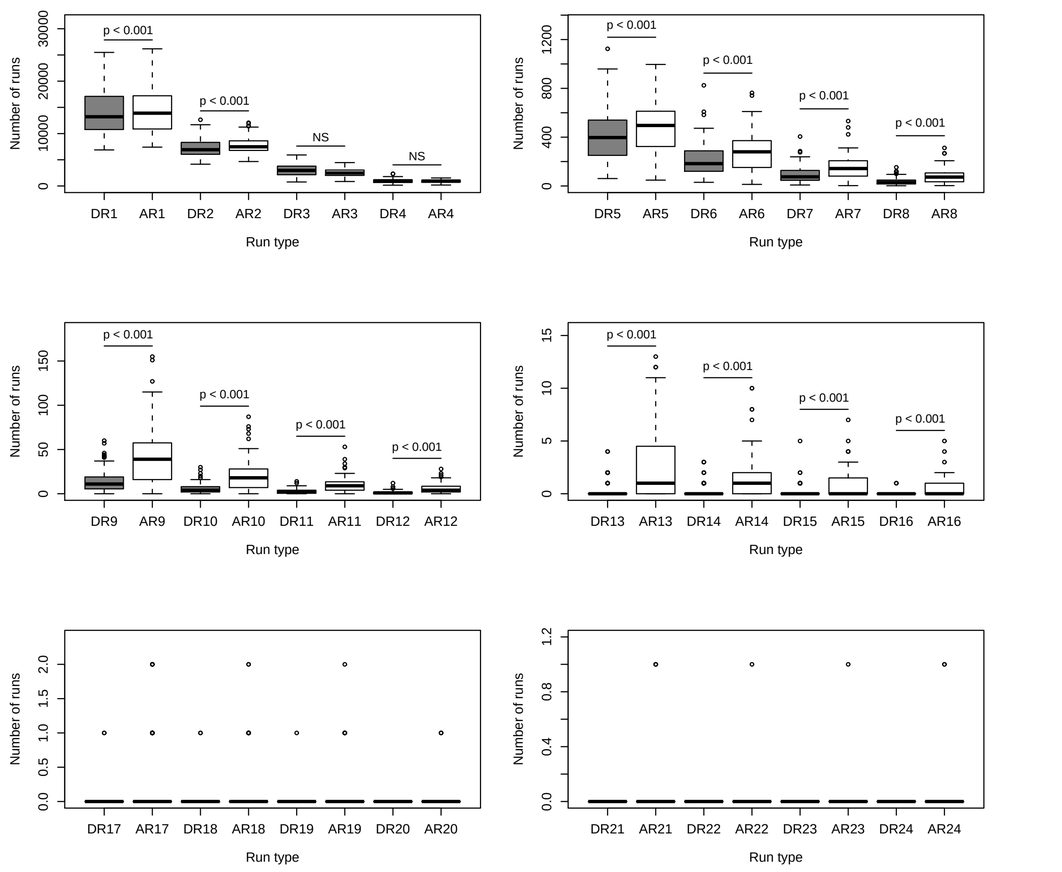






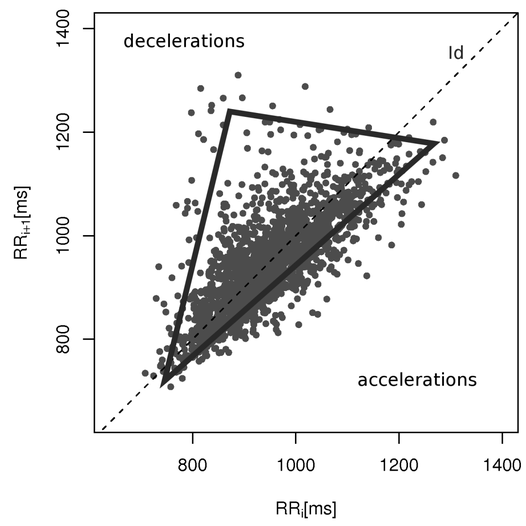
3.2 Runs duration

Deceleration runs of length 1, 2 and 3 have highly significantly longer duration, runs 4 to 7 do not differ in duration and for the remaining lengths, 8 – 16 deceleration runs are again longer than acceleration runs. It is impossible to calculate the *p*-value for longer runs, because many of them were not represented in the analyzed recordings. For details see the figure below.



4 Conclusion

The greater length of acceleration runs is compensated for by a greater duration of deceleration runs. This is another evidence evidence of a mechanism which keeps the heart rhythm within a certain set of values balancing two processes – more dynamic deceleration runs and gradual and more numerous accelerations (by *more dynamic* we mean changing the heart rhythm more than acceleration runs within the same number of runs).
Earlier, some evidence of such a mechanism was found in the variance-based HRA descriptors - in short, the short term asymmetry, which states that over short term decelerations contribute more to short-term variability, is balanced out in longer term by long term asymmetry, in which accelerations prevails [5]. An example of a Poincaré plot in which this is clearly visible can be found below.



In this paper we have established the existence of such a phenomenon in the distributions and durations of monotonic runs. We have also studied the above distributions and found yet another piece of evidence for HRA.

5 References

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