Heart Rate Variability Analysis: Effects of Handgrip Exercise

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1 Introduction

Heart Rate Variability (HRV) is a measure of the variation in the time intervals between heartbeats. It reflects the balance between the sympathetic and parasympathetic nervous systems, which control involuntary bodily functions. Handgrip exercise is known to activate the sympathetic nervous system, which can influence HRV. The aim of this study is to assess differences in the responses to the same stimulus and to study how the chosen parameters reflect the autonomic regulation.

2 Methods

2.1 Data Processing

- The R-R interval data of 2 subjects was imported into Kubios for analysis (SitHandgrip1.txt, SitHandgrip2.txt).
- The data was segmented into two 4-minute samples for analysis, ensuring a stable period for both the resting and handgrip phases. The first sample (resting) interval is: $[0:00, 4:00]$ and the second (handgrip): $[6:00, 10:00]$

2.2 HRV Analysis

The following HRV parameters were calculated for both the resting and handgrip periods:

- **Time-domain parameters:**
  - Mean Heart Rate (HR)
  - Standard Deviation of RR Intervals (SDNN)
- **Frequency-domain parameters:**
  - Low-frequency power (LF)
  - High-frequency power (HF)
  - LF/HF ratio

In addition, Poincarè plots and R-R distributions are shown.

3 Results

3.1 Subject 1

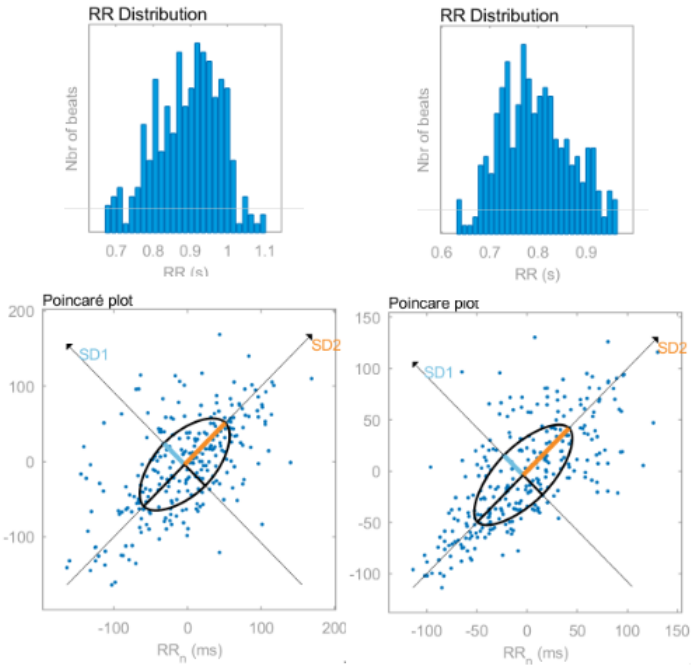

Figure 1: Poincaré plot for Subject 1 (Resting and Handgrip Periods).

Parameter	Resting	Handgrip
HR (bpm)	67	75
SDNN (ms)	62.1	49.6
LF (ms^2)	2546	1416
HF (ms^2)	1514	814
LF/HF ratio	1.682	1.739

3.2 Subject 2

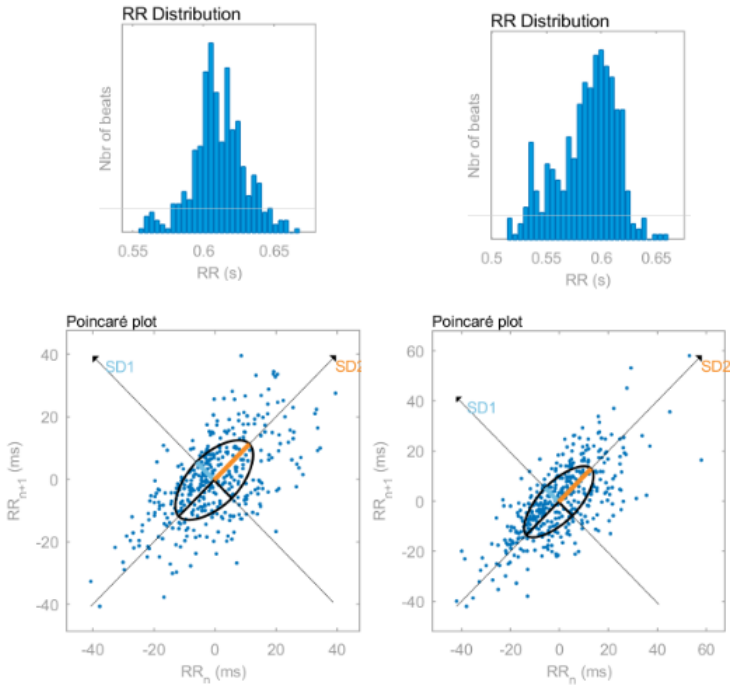

Figure 2: Poincaré plot for Subject 2 (Resting and Handgrip Periods).

Parameter	Resting	Handgrip
HR (bpm)	98	102
SDNN (ms)	12.9	14.4
LF (ms^2)	99	113
HF (ms^2)	24	32
LF/HF ratio	4.066	3.576

4 Discussion

4.1 General Discussion:

The responses of Subject 1 and Subject 2 highlight significant individual variability in autonomic responses to the same physical task. Indeed, the R-R distributions are very different from subject to subject. This could be influenced by factors such as fitness, age, or differences in autonomic nervous system regulation. These findings underscore the importance of individual differences in HRV analysis and suggest that physiological responses to the same stimulus are not uniform across individuals. In addition, the Poincarè plots are also fairly diverse. We can observe that during the hand grip, the sympathetic activation dominates making the cluster tighter.

4.1.1 HR

Both subjects experienced an increase in HR during the handgrip exercise, suggesting an activation of the sympathetic nervous system in response to the physical effort.

4.1.2 SDNN

Subject 1's SDNN decreased during the handgrip period, indicating reduced overall HRV and suggesting increased cardiac sympathetic modulation or decreased parasympathetic influence. Subject 2's SDNN slightly increased during the handgrip period, but the magnitude of change is small. This may suggest a more balanced autonomic response to the exercise.

4.1.3 LF

LF decreased for Subject 1 during the handgrip exercise, suggesting reduced sympathetic modulation. This is slightly unexpected given that sympathetic activation is typically dominant during physical activity. LF increased for Subject 2, consistent with increased sympathetic activity during handgrip.

4.1.4 HF

HF decreased for Subject 1, indicating reduced parasympathetic activity, as expected during physical activity. HF slightly increased for Subject 2, which could imply individual variability in autonomic responses or differences in baseline parasympathetic activity. This may be correlated to its SDNN changes.

4.1.5 LF/HF

Subject 1's LF/HF ratio remained fairly stable, with a slight increase during handgrip. This indicates a marginal shift toward sympathetic dominance but also reflects a relatively balanced autonomic response. Subject 2's LF/HF ratio decreased during handgrip, suggesting a relative reduction in sympathetic dominance. This could be due to individual physiological differences or lower baseline variability as discussed previously about SDNN and HF.

4.2 Research process discussion

The performed analysis cannot be considered significant, as only two subjects were analyzed. Furthermore, the data collection process was not considered at all, as the data was already pre-prepared. Indeed, the "anomalies" in Subject 2 may be due to incorrect data gathering procedures. Moreover, many additional parameters should be considered to obtain statistically significant results. As observed, data from two individuals can vary significantly. Therefore, a larger dataset is necessary. Additionally, there was no control group, and the analysis did not account for different handgrip intensity levels or more rest-physical activity cycles.