# Methods & Results Section

## Contents



# 1 Methods

Data analyses were carried out in R version 3.5.0 (2018-04-23) and Python 2.7. In accordance with previous studies examining the relation between HRV and discrete eating episodes (Friesen et al. 2007; Harthoorn and Dransfield 2007; Ranzenhofer et al. 2016), physiological data collected in the 30-minute period preceding the eating episode were examined. For each participant, the inter-beat interval (IBI) for each self-reported survey was selected, where surveys were either self-reported at the time of an eating episode, or pseudo-randomly triggered in the app. This resulted in an initial total of $n = 487$ emotional eating episodes and $n = 3155$ control episodes before cleaning the data.

Using the RHRV package (Rodriguez-Linares et al. 2017), IBI data streams were filtered, interpolated, and artifacts were removed, using thresholds and parameters in compliance with normative reported values for heart rate variability features (Shaffer and Ginsberg 2017). Observations that did not meet normative criteria were removed. Consistent with existing research, features of heart rate variability were extracted from both the time and frequency domain to measure both the amount of variability and the amount of signal energy in the 30-minute period (Shaffer and Ginsberg 2017; Rubin et al. 2016).

The following heart rate variability features were extracted from the IBI streams for each observation in the time domain: *SDNN* (Standard Deviation of all filtered inter-beat intervals); *SDANN* (Standard Deviation of inter-beat intervals between all successive heartbeats); *SDNNIX* (Mean of the standard deviations of all the filtered inter-beat intervals for each 5 min segment of the IBI stream); *pNN50* (Percentage of successive inter-beat intervals that differ by more than 50 ms); *SDSD* (Standard Deviation of Successive Differences of inter-beat intervals); *rMSSD* (Root Mean Square of Successive Differences); *IRRR* (length of the interval determined by the first and the third quantile of the inter-beat interval); *MADRR* (Median of the Absolute values of the successive Differences between the inter-beat intervals); *TINN* (Triangular Interpolation of inter-beat interval histogram); and *HRVi* (Heart Rate Variability index) (Rodriguez-Linares et al. 2017).

*SDNN* reflects the power of the components responsible for variability in heart rhythm, while *SDANN*, *SDNNIX*, *pNN50*, *SDSD*, *rMSSD*, *IRRR*, and *MADRR* reflect different statistical aspects of the high frequency variation in heart rhythm. Finally, *TINN* and *HRVi* represent geometric measures calculated from the density distribution of inter-beat intervals (Rodriguez-Linares et al. 2017).

In the frequency domain, features extracted included the mean non-interpolated heart rate (*mean niHR*), the mean interpolated Heart Rate (*mean HR*), and the heart rate values at the start and end of the 30 minute window (*Start HR*, *End HR*). Additional frequency domain features were extracted from the 30 minute streams by applying a Fourier transform to the heart rate signal, resulting in a spectrogram of the heart rate in the low and high frequency ranges. To extract a sufficient amount of information from these spectograms and increase the variance of our data, the spectrogram was split into 5 minute windows, as has been done previously in studies using heart rate variability to predict event-level behavior (Rubin et al. 2016). Mean features were extracted from each of these windows — the mean Low Frequency signal ($LF_1$, $LF_2$,... $LF_6$), the mean High Frequency signal ($HF_1$, $HF_2$,... $HF_6$), and the mean Low Frequency-High Frequency Ratio ($LFHF_1$, $LFHF_2$,... $LFHF_6$).

In order to examine any differences between means of the features, and address the issue of group imbalance affecting statistical power, we conducted between-groups permutation T-tests with each variable in the time and frequency domain (Maindonald and Braun 2015; Good 2013). Then, using the CARET package (Jed Wing et al. 2018), a Support Vector Machine with a polynomial kernel was implemented to predict episodes from controls. In order to address the group imbalance in this stage, all features were standardized, while controls were randomly downsampled and episodes were randomly upsampled using the ROSE package (Lunardon, Menardi, and Torelli 2014). To evaluate model performance, models were tested using 4-fold cross validation, training models on 3/4 of the data and using the remaining data evaluate the model accuracy, specificity, and sensitivity.

# 2 Results

## 2.1 Missingness

After cleaning the dataset of erroneous surveys (e.g. no usable IBI data; overlapping survey responses; control observations with high self-reported stress), and filtering IBI streams that did not meet filtering quality criteria for preprocessing, the data consisted of $n = 285$ emotional eating episodes and $n = 1753$ controls. Of these clean observations, HRV features were extracted from the IBI streams, although even with filtering, many IBI streams were too sparse to compute HRV features. Figures 1 and 2 summarise the completeness of data in the extracted time and frequency domain features.

MENTION HOW MANY CONTROLS AND EPISODES HERE (FOR SDNN we have n and for the remaining we have n range)

## 2.2 Comparison of Means

FILTER OUT HIGH STRESS CONTROLS AND REPORT PERMUTATION T

The mean values for each time-domain features is shown in Table 1 below:

Table 1: Summary of Time Domain Features

| variable | n | mean | sd |
|---|---|---|---|
| HRVi | 129 | 7.171186 | 1.992292 |
| IRRR | 129 | 65.288888 | 28.536286 |
| MADRR | 129 | 26.043073 | 10.932954 |
| pNN50 | 129 | 19.830466 | 10.590042 |
| rMSSD | 129 | 48.539227 | 13.137957 |
| SDANN | 129 | 15.440406 | 15.451301 |
| SDNN | 1537 | 69.429465 | 24.835250 |
| SDNNIDX | 129 | 43.869882 | 12.781756 |
| SDSD | 129 | 48.557984 | 13.143443 |
| TINN | 129 | 112.049788 | 31.129567 |

Using a Two $t$ permutation test run between episodes and controls, none of the time-domain variables were found to be significantly different, shown in Table 2.

A similar approach was taken to analyze the frequency domain. The table below outlines the mean values of features:

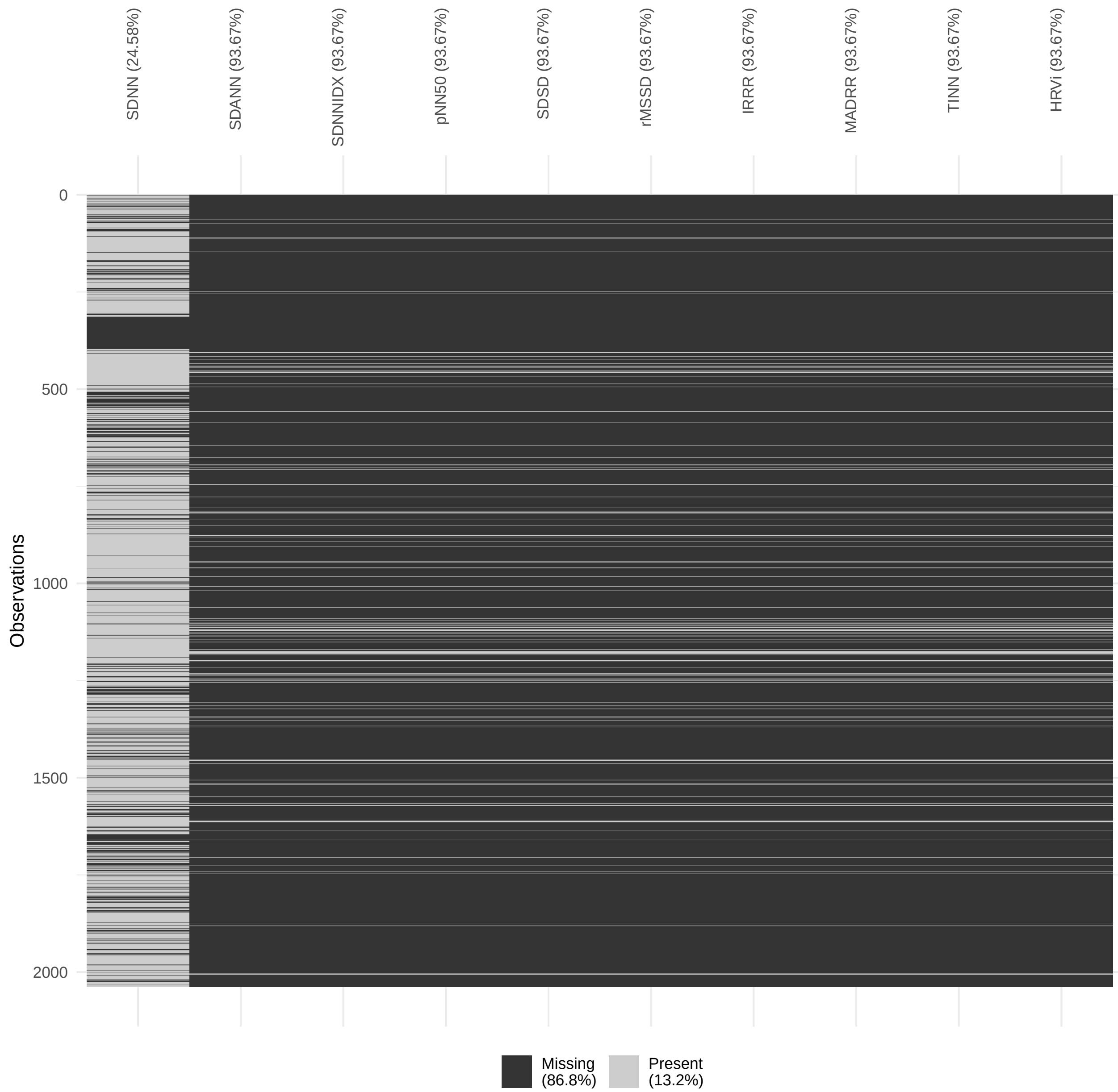



Figure 1: Completeness of Features in the Time Domain

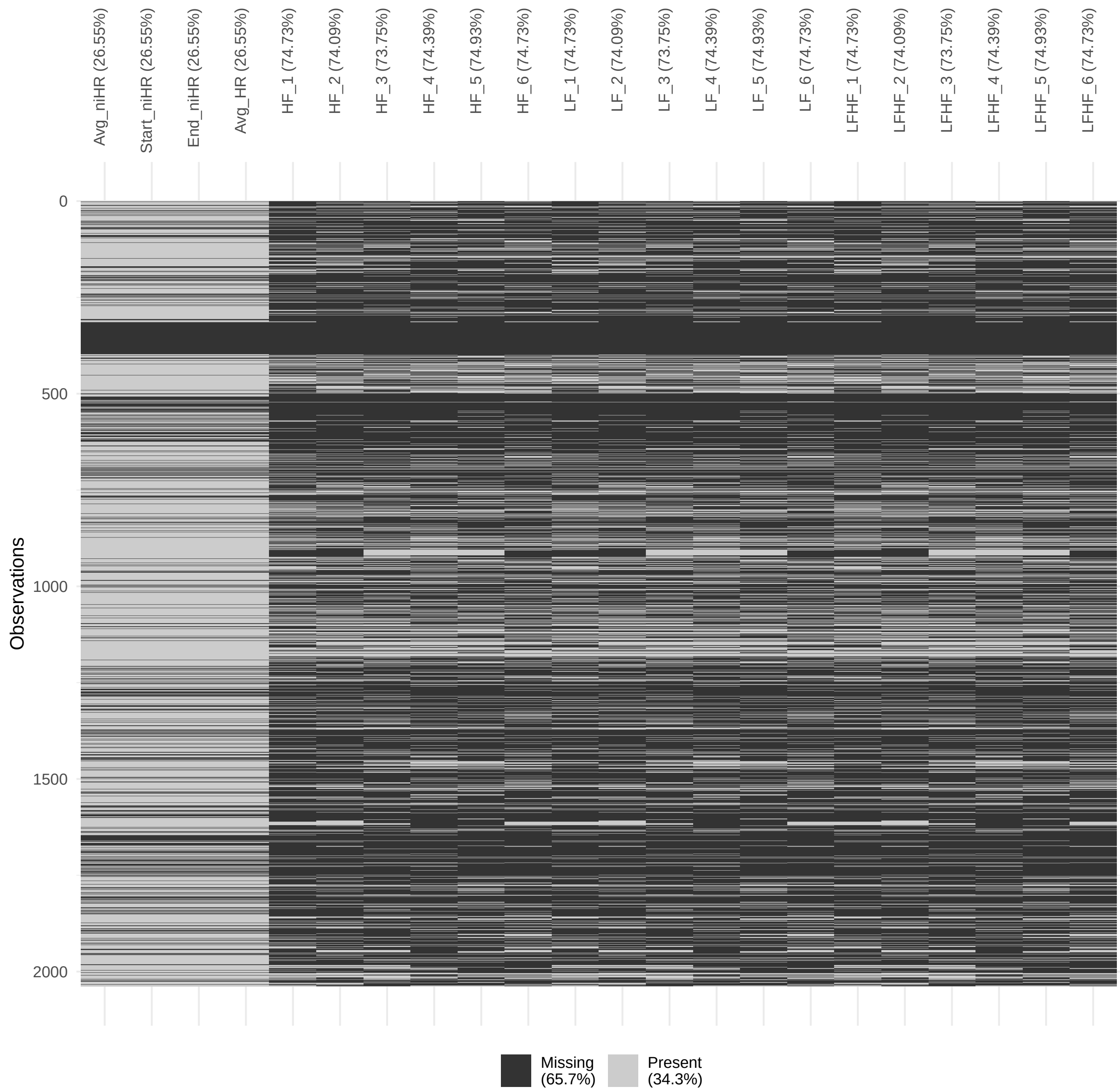



Figure 2: Completeness of Features in the Frequency Domain

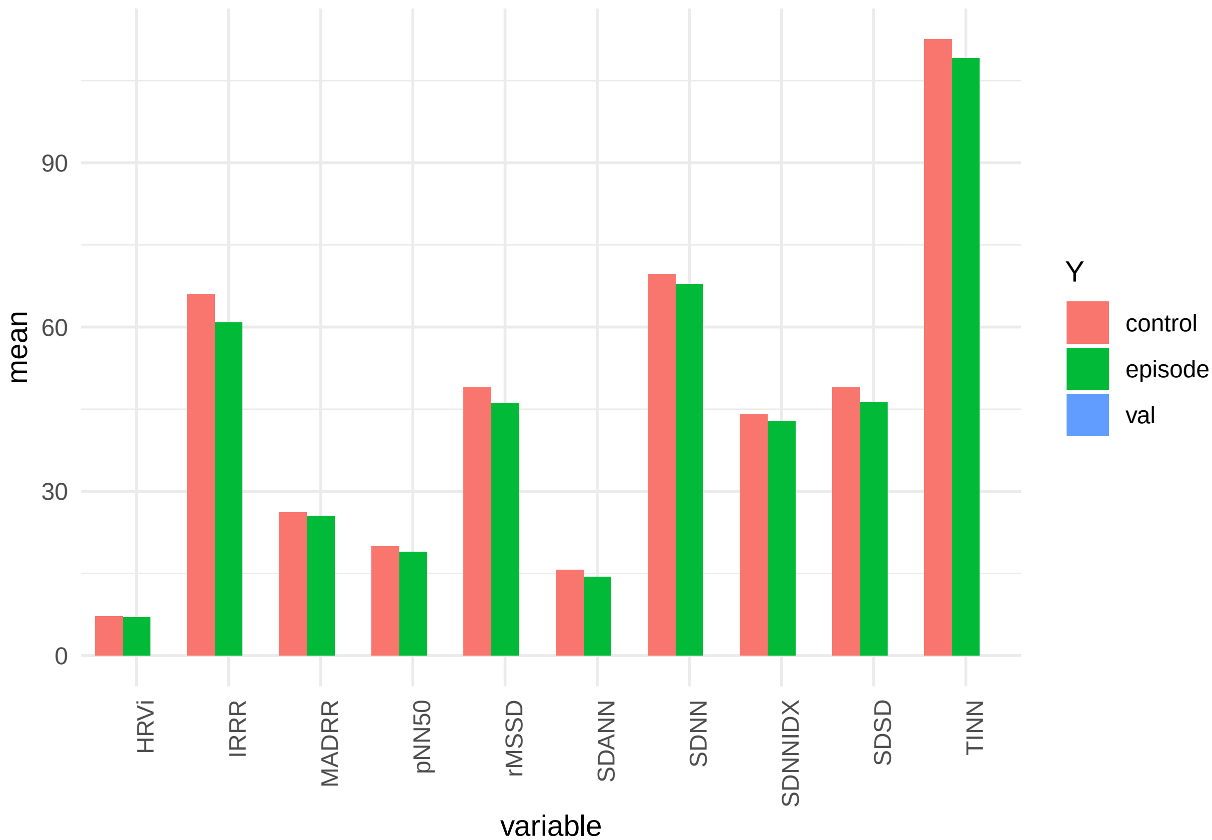



Figure 3: Between-Groups Permutation $t$-test of Time Domain Features

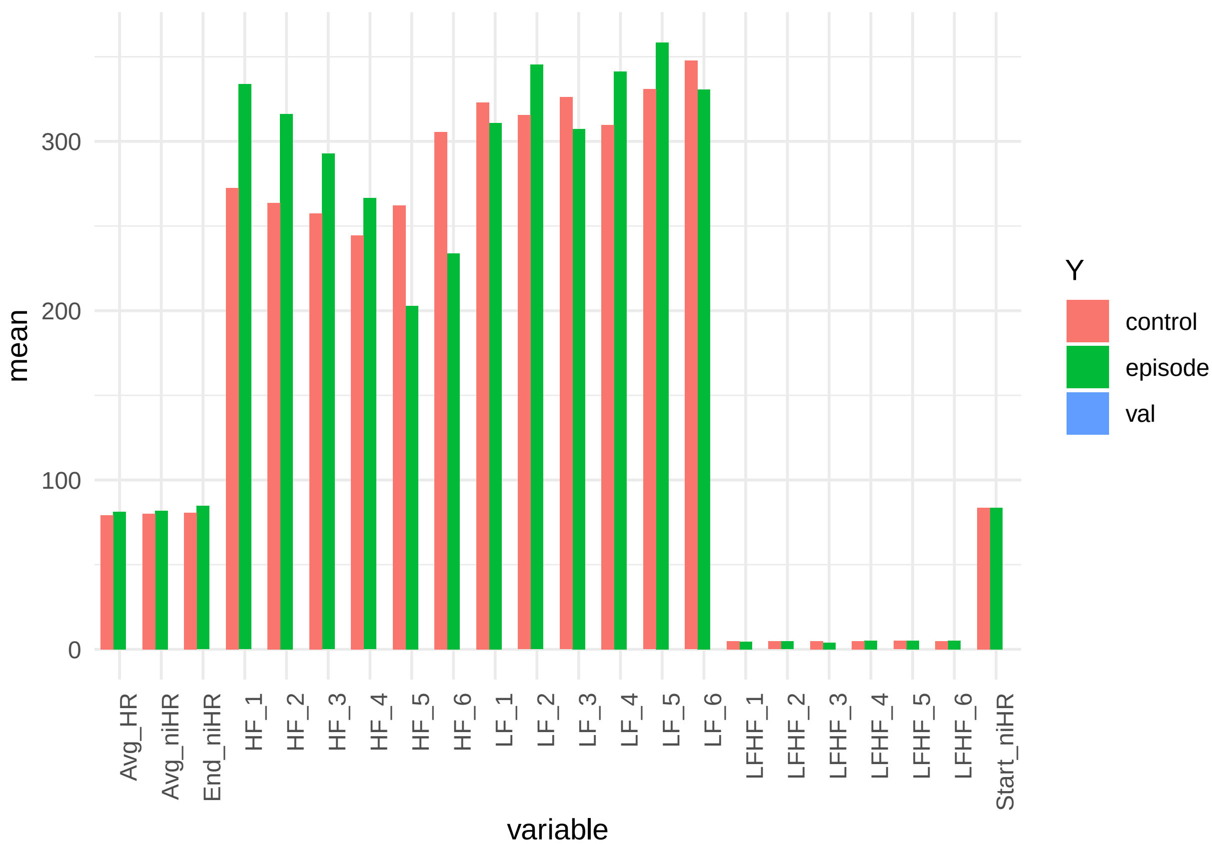
Table 2: Between-Groups Permutation $t$-test of Time Domain Features

| variable | mean.control | mean.episode | n.control | n.episode | sd.control | sd.episode | p.val |
|---|---|---|---|---|---|---|---|
| HRVi | 7.20 | 6.98 | 110 | 19 | 2.12 | 1.04 | 0.66 |
| IRRR | 66.05 | 60.86 | 110 | 19 | 30.50 | 11.52 | 0.47 |
| MADRR | 26.14 | 25.49 | 110 | 19 | 11.22 | 9.33 | 0.73 |
| pNN50 | 19.99 | 18.93 | 110 | 19 | 10.93 | 8.54 | 0.69 |
| rMSSD | 48.95 | 46.17 | 110 | 19 | 13.61 | 9.95 | 0.39 |
| SDANN | 15.62 | 14.40 | 110 | 19 | 16.33 | 9.02 | 0.74 |
| SDNN | 69.69 | 67.87 | 1318 | 219 | 25.23 | 22.32 | 0.31 |
| SDNNIDX | 44.04 | 42.86 | 110 | 19 | 13.45 | 8.05 | 0.70 |
| SDSD | 48.97 | 46.19 | 110 | 19 | 13.61 | 9.96 | 0.39 |
| TINN | 112.55 | 109.14 | 110 | 19 | 33.06 | 16.20 | 0.66 |

| variable | n | mean | sd |
|---|---|---|---|
| Avg_HR | 1497 | 79.50 | 12.13 |
| Avg_niHR | 1497 | 80.26 | 12.20 |
| End_niHR | 1497 | 81.34 | 15.69 |
| HF_1 | 515 | 282.34 | 382.80 |
| HF_2 | 528 | 271.35 | 351.14 |
| HF_3 | 535 | 262.68 | 291.35 |
| HF_4 | 522 | 248.05 | 289.56 |
| HF_5 | 511 | 254.59 | 317.44 |
| HF_6 | 515 | 295.68 | 432.77 |
| LF_1 | 515 | 320.98 | 254.62 |
| LF_2 | 528 | 319.81 | 246.48 |
| LF_3 | 535 | 323.36 | 247.22 |
| LF_4 | 522 | 314.75 | 238.92 |
| LF_5 | 511 | 334.37 | 253.86 |
| LF_6 | 515 | 345.29 | 269.47 |
| LFHF_1 | 515 | 4.69 | 3.42 |
| LFHF_2 | 528 | 4.68 | 3.53 |
| LFHF_3 | 535 | 4.59 | 3.46 |
| LFHF_4 | 522 | 4.83 | 3.55 |
| LFHF_5 | 511 | 4.98 | 3.55 |
| LFHF_6 | 515 | 4.85 | 3.42 |
| Start_niHR | 1497 | 83.58 | 17.76 |

Using the same Two-$t$ permutation approach, we found signficant differences in means for Average Heart Rate, Average non-interpolated Heart Rate, Ending non-interpolated Heart Rate, and the LF-HF ratio in the third window.

| variable | mean.control | mean.episode | n.control | n.episode | sd.control | sd.episode | p.val |
|---|---|---|---|---|---|---|---|
| Avg_HR | 79.22 | 81.20 | 1282 | 215 | 12.25 | 11.30 | 0.03 |
| Avg_niHR | 80.01 | 81.76 | 1282 | 215 | 12.31 | 11.41 | 0.05 |
| End_niHR | 80.77 | 84.71 | 1282 | 215 | 15.55 | 16.12 | 0.00 |
| HF_1 | 272.59 | 333.79 | 433 | 82 | 329.02 | 591.06 | 0.18 |
| HF_2 | 263.68 | 316.23 | 451 | 77 | 305.91 | 546.34 | 0.22 |
| HF_3 | 257.48 | 292.74 | 456 | 79 | 257.94 | 438.11 | 0.31 |
| HF_4 | 244.61 | 266.51 | 440 | 82 | 259.52 | 416.97 | 0.55 |
| HF_5 | 262.25 | 202.95 | 445 | 66 | 335.09 | 143.31 | 0.14 |
| HF_6 | 305.57 | 233.80 | 444 | 71 | 460.86 | 163.01 | 0.18 |
| LF_1 | 322.90 | 310.85 | 433 | 82 | 255.19 | 252.93 | 0.70 |
| LF_2 | 315.46 | 345.28 | 451 | 77 | 245.66 | 251.30 | 0.33 |
| LF_3 | 326.12 | 307.45 | 456 | 79 | 253.17 | 210.27 | 0.53 |
| LF_4 | 309.79 | 341.38 | 440 | 82 | 235.44 | 256.66 | 0.27 |
| LF_5 | 330.80 | 358.43 | 445 | 66 | 252.93 | 260.77 | 0.41 |
| LF_6 | 347.62 | 330.70 | 444 | 71 | 273.40 | 244.74 | 0.63 |
| LFHF_1 | 4.72 | 4.57 | 433 | 82 | 3.46 | 3.20 | 0.71 |
| LFHF_2 | 4.68 | 4.67 | 451 | 77 | 3.50 | 3.72 | 0.97 |
| LFHF_3 | 4.72 | 3.86 | 456 | 79 | 3.49 | 3.19 | 0.04 |
| LFHF_4 | 4.78 | 5.09 | 440 | 82 | 3.54 | 3.60 | 0.46 |
| LFHF_5 | 4.98 | 5.02 | 445 | 66 | 3.52 | 3.74 | 0.94 |
| LFHF_6 | 4.80 | 5.14 | 444 | 71 | 3.43 | 3.35 | 0.44 |
| Start_niHR | 83.56 | 83.70 | 1282 | 215 | 18.21 | 14.85 | 0.92 |



## Machine Learning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