Survival Analysis Using Time-Frequency Analysis of heart Rate Variability During Exercise

Heart rate variability (HRV) refers to changes in time between heart beats over time and has been well established as a risk factor for, or associated with, all-cause mortality after experiencing myocardial infarction, post-traumatic stress disorder and irritable bowel syndrome, among other things. The work presented in this paper presents an evaluation of time-frequency indices of HRV changes extracted from over 100,000 ECG recordings for seven minutes long exercise bike tests. A link between said indices and increased risk of experiencing cardiac events was established.

Heart rate variability is used to gain a measure of neural activity in the human body, where different frequencies of change in heart rate correspond to different parts of our nervous system. The reason why HRV is an appealing measure to use for gauging nervous activity as opposed to directly measuring it is that it can be registered by non-invasive means instead of for example drawing blood samples. This can be achieved via for example electrodes on the skin or pulse oximeters.

This work is based on ECG-recordings during exercise, where participants have cycled on an exercise bike for seven minutes at different workloads while being recorded. From this recording, the time between heart beats can be extracted via thresholding algorithms. Subsequently, the changes in this beat-to-beat time is extracted. Because these recordings are taken from individuals during increasing levels of exercise, a method for handling changing (i.e. non-stationary) heart rate is necessary. As the resistance on the bike becomes higher, the participants' heart rates will increase. With a higher heart rate comes a lower HRV, and so to study HRV over a non-stationary process a time-frequency approach was used.

Time-frequency methods allow us to see frequency contents in a signal for a given time, something which for example a Fourier transform would not be able to. By looking at the time-frequency distribution of HRV, an estimate of its near-instant changes is achievable. These estimates have been proven to remain stable over three years the part of the participants who took the exercise bike test twice, and one has also proven to be linked with increased risk of suffering from cardiac events such as heart attacks. The resulting link goes against previously established knowledge about HRV, which may be due to the fact that previous studies have not looked at such a large population before.

The individuals who partook in the study are non-clinical, that is they were not recruited because they were showing any form of symptoms. Instead, this study mostly consisted of data from healthy individuals. This means that the results from this project can be applied as a form of screening methodology, which in theory could be implemented in exercise bikes located in for example gyms or in your home.