Sleepiness on Task can be Detected Using Heart Rate Fluctuations

Gabriela Dorfman Furman¹, Clement Cahan², Anda Baharav²,³

(1) Tel Aviv University, Tel Aviv, Israel; (2) Sleep Disorders Clinic, Shaare Zedek Medical Center, Jerusalem, Israel; (3) HypnoCore, Yehud, Israel;

Introduction

Complex regulatory and biofeedback systems rule human function and behavior. Sleep is vital, ruled by homeostatic balance and circadian oscillations. Sleepiness represents an important causal factor for accidents and daytime malfunction. Analysis of instantaneous fluctuations in heart rate allows to estimate the cardiac autonomic regulation at the sinus node level¹ and represents a window to other complex physiological functions such as sleep and wakefulness.² Our goal is to find a non-invasive method to predict involuntary falling asleep on task, mainly while driving.

Methods

- The present study was performed on 10 healthy volunteers.
- The study involved a 34-hour sleep deprivation protocol including two alternating tasks:
  - A standard, passive, 45 minute Maintenance of Wakefulness Test (MWT).
  - A 90 kilometer Driving Simulation (DS).
- During the entire protocol electroencephalogram (EEG), electromyogram (EMG), eye movements (EOG), electrocardiogram (ECG) as well as audio-video were continuously monitored, recorded, and later analyzed offline.
- Microsleeps (MS) lasting for 3-15 seconds and falling asleep (FA) events lasting 15-120 seconds were detected from ECG and EOG analysis.
- The ECG was analyzed using R-R interval (RRI)
  - Behavior in the time domain,
  - Time-frequency decomposition
  - Entropy
  - Poincare plots (n+1).

Results

- The sleep deprivation setting created a large number of MS and FA events during both active DS test and passive MWT tasks.
- Time domain analysis was applied to RRI as a function of time awake, and was normalized to the personal average before first MS (B4MS). The values of some parameters after the first MS (AFMS) differed significantly for most calculated parameters, both for MWT and for DS.

Conclusions

- We can thus conclude that the first MS represents a cutoff point in the behavior of HRV based on a number of calculated parameters in the time and time frequency domains.
- There are clear HRV markers that indicate sleepiness in sleep deprived subjects. It remains to find if these markers are relevant in non-sleep deprived subjects while performing the same tasks. Provided some of these variables show the same trends, a threshold should be defined as to imminent danger while driving and when a subject should be stopped from continuing a task.

References