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Increased Heart Rate Variability predicts fatigue before and after sleep deprivation and might be related to compensatory mechanisms in the CNS

Introduction:

Sleep deprivation has influences on several body functions. Cardiologic diseases have been associated with night time workers. Cognitive fatigue, probably caused by a dysfunction of basal ganglia is increased after sleep deprivation. Brain structures involved with fatigue are interconnected with the supraspinal autonomic network, which again is involved in heart rate variability changes.

Method:

A 10 minute HRV-measurement was obtained before and after night shift in nighttime workers (nurses). Possible participants with diabetes, heart diseases of all kind, use of Beta Blockers, ACE-inhibitors, Angiotensin II receptor antagonists, Digitalis, tricyclic antidepressants or with other clinical relevant diseases were excluded. Participants were in addition asked about their subjective fatigue (verbal rating scale) before and after the night shift. From the time series linear parameters (SDNN, rMSSD, TP, HF, LF, VLF, LF/HF) and nonlinear parameters (approximate entropy, Renyi entropy, Shannon entropy, and as fractal measures capacity dimension (Renyi Dimension D0) and information dimension (Renyi Dimension D1) were calculated.

Results: At all 23 participants, 79.2 % female, mean age 41 (25-63 years) were included. Fatigue before nightshift was 12 (0-60, std dev 14.8), after nightshift 49 (10-85. Std dev 20.13). Linear and nonlinear parameters were not statistically different before and after the night shift. Cluster analysis revealed two different groups with significantly different levels of fatigue in the morning, one with less fatigue (38.3, std. dev. 17.7) and one with increased fatigue (56,9, std. dev. 18.7). Both SDNN, RMSSD and Renyi entropy with α = 1, 2 and 3 was increased in persons with higher fatigue after nightshift. SDNN was also increased significantly before the nightshift in this group. SDNN, RMSSD and Renyi entropy α = 0 and 1 before nightshift was significantly higher in persons with fatigue > 50 on the verbal rating scale after nightshift. Participants with SDNN > 70 before nightshift had more frequently a fatigue score > 50 afterwards (p = 0.008) with a likelihood ratio of 8,416, which reflects a positive predictive value of 87,5 %, and a negative predictive value of 73 %.

Discussion

Our results indicate that sleep deprivation does not have effects on HRV indices. This is in accordance to results of other studies, with exception of one study with 10 permanent night shift nurses where LF/HF was increased. Our results indicate however an association between higher SDNN, different entropy indices and a tendency for lower LF/HF and fatigue. SDNN is a global parameter for heart rates variability and is increased eg. by exercise, but also by pathological factors like increased CRP. It has also been shown that it increases during the night while sleeping. All participants drank some coffee in the morning before testing but coffee had no influence on HRV in healthy participants. The increased SDNN might be caused by a compensation effort of the prefrontal cortex to control the anterior cingulated cortex (which known to be overactive in fatigue conditions).