**Effects of sleep deprivation on autonomic and endocrine functions throughout the day and on exercise tolerance in the evening**

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**Introduction**

Sleep deprivation induces autonomic and endocrine dysfunction and is associated with cardiovascular diseases. However, the establishment of clear etiological relationships has not been reached because sleep deprivation studies have reported varied and often conflicting effects on autonomic and hormonal output caused by time-of-day effects. Sleep deprivation may also impair exercise tolerance by disrupting compensatory autonomic and endocrine responses; but again results have been inconsistent. Therefore, we investigated the effects of sleep deprivation on autonomic and endocrine functions throughout the day and on exercise tolerance in the evening.

**Methods**

Ten healthy young males completed two, 2-day control and sleep deprivation trials. For the control trial, participants were allowed normal sleep from 2300 to 0700. For the sleep deprivation trial, participants did not sleep for 34 h. Autonomic regulation was measured from 1900 on day 1 to 1600 on day 2 by frequency-domain measures of heart rate variability (HRV). Endocrine function was examined by measuring adrenocorticotropic hormone (ACTH) and cortisol from venous blood samples collected on day 2 at 0900, 1300, and 1700 and immediately after an exercise tolerance testing. Exercise tolerance testing was performed on a treadmill until exhaustion by a ramp protocol at 1700 on day 2.

**Results**

Autonomic regulation, particularly parasympathetic regulation estimated from the high-frequency component of HRV analysis, was significantly higher in the sleep deprivation trial than in the control trial at 1400 to 1600 on day 2 (P < 0.01). Plasma ACTH concentrations were significantly higher at 0900 and 1300 of day 2 under sleep deprivation (P < 0.05, respectively), but plasma cortisol concentrations were not affected by sleep deprivation. Heart rate during the exercise tolerance testing was significantly lower following sleep deprivation than following normal sleep (main effects of the trial, P < 0.05).

**Discussion and Conclusion**

Our findings demonstrated clear time-of-day effects of sleep deprivation on autonomic regulation, with markedly increased parasympathetic regulation in the late afternoon. Moreover, the results of high ACTH and low cortisol concentration in sleep deprivation indicate that sleep deprivation may induce abnormalities in the hypothalamic-pituitary-adrenocortical axis function. These two effects may contribute to the decreased heart rate during exercise tolerance testing in the evening following sleep deprivation. In conclusion, these findings suggest that effects of sleep deprivation on autonomic regulation are dependent on the time of the day. These time-of-day effects may account for many inconsistencies reported in previous studies of autonomic and endocrine functions and studies on exercise tolerance under sleep deprivation.

**References**