Sleep and circadian influences on cardiac autonomic nervous system activity

HELEN J. BURGESS, JOHN TRINDER, YOUNG KIM, AND DAVID LUKE
Department of Psychology, University of Melbourne, Parkville, Victoria 3052, Australia

Burgess, Helen J., John Trinder, Young Kim, and David Luke. Sleep and circadian influences on cardiac autonomic nervous system activity. *Am. J. Physiol.* 273 (*Heart Circ. Physiol.* 42): H1761–H1768, 1997.—To assess the separate contributions of the sleep and circadian systems to changes in cardiac autonomic nervous system (ANS) activity, 12 supine subjects participated in two 26-h constant routines, which were counterbalanced and separated by 1 wk. One routine did not permit sleep, whereas the second allowed the subjects to sleep during their normal sleep phase. Parasympathetic nervous system activity was assessed with respiratory sinus arrhythmia as measured from the spectral analysis of cardiac beat-to-beat intervals. Sympathetic nervous system activity was primarily assessed with the preejection period as estimated from impedance cardiography, although the 0.1-Hz peak from the spectral analysis of cardiac beat-to-beat intervals, the amplitude of the T wave in the electrocardiogram, and heart rate were also measured. Respiratory sinus arrhythymia showed a 24-h rhythm independent of sleep, whereas preejection period only showed a 24-h rhythm if sleep occurred. Thus the findings indicate that parasympathetic nervous system activity is mostly influenced by the circadian system, whereas sympathetic nervous system activity is mostly influenced by the sleep system.

parasympathetic; spectral analysis; T wave; preejection period

DETERMINATION OF THE NATURE of the influence of sleep on cardiac activity is of considerable interest because of its potential clinical relevance. For example, there are cardiovascular consequences of the nighttime arousals that occur in disorders such as sleep apnea (29). It is generally accepted that compared with wakefulness (usually assessed just before sleep), non-rapid eye movement (NREM) sleep in humans is associated with an increase in cardiac parasympathetic nervous system (PNS) activity [as measured by noninvasive methods such as respiratory sinus arrhythmia (RSA)] (2, 23, 32–35, 37). More specifically, most agree that PNS activity progressively increases across the four stages of NREM sleep (21, 32, 34, 36), although not all have found this (35, 37). In rapid eye movement (REM) sleep, PNS activity appears to decrease compared with NREM sleep (2, 21, 23, 32–34, 36, 37).

Noninvasive cardiac measures (such as the 0.1-Hz peak derived from the spectral analysis of heart beat-to-beat intervals) indicate that sympathetic nervous system (SNS) activity decreases slightly or remains unchanged in the transition from wakefulness to NREM sleep (2, 23, 32–37). However, in humans, recordings of the sympathetic innervation of skeletal muscle blood vessels have shown a marked progressive fall in sympathetic activity with deepening NREM sleep (16, 22, 30, 31). It remains unclear whether this difference is a function of the invasiveness of the methodology or central versus peripheral autonomic activity. In REM sleep, SNS activity has been found to decrease (2, 25), increase (16, 21, 22, 30, 32, 34, 35), or show no change (23, 33, 36) relative to NREM sleep regardless of whether the measurement technique was invasive. These contradictory findings are probably due to studies failing to distinguish between tonic and phasic SNS activities. Thus SNS activity in tonic REM sleep may decrease slightly compared with NREM sleep and increase with occasional bursts during phasic REMs and myoclonic twitches (2, 16, 25).

In addition to the influence of sleep on autonomic nervous system (ANS) activity, there has been interest recently in a possible circadian influence on ANS activity. This interest stems from reports of an increased incidence of cardiovascular events in the morning (e.g., Ref. 20). However, the existence of an endogenous circadian influence on ANS activity has not yet been established because the majority of past studies have either failed to control for the confounding effects of sleep (13) or because of changes in posture and physical activity (e.g., Ref. 12). With these factors controlled for, PNS activity has shown no change (9, 32) or a decrease during the daytime (5, 14), with SNS activity remaining relatively stable (5, 14, 18, 32). In this study, ANS activity was assessed over two 26-h periods while subjects were supine and their activity was kept to a minimum. During one period, the subjects were allowed to sleep during their normal sleep period (circadian and sleep influence present), whereas in the other, they were not (circadian influence present). It was hypothesized that both the PNS and SNS would be affected by sleep but that only the PNS would be influenced by the circadian system.

METHODS

Subjects

Twelve male subjects [19.0 ± 2.3 (SD) yr] of average body mass index (20.97 ± 1.74 kg/m^2) participated. Women did not participate because of their toileting requirements. The subjects were free of physical illness, nonsmokers, and not taking any medication (currently or in the past week), regular heavy caffeine (<350 mg/day), or alcohol doses (≤5 standard drinks/wk). The subjects participated in a moderate amount of exercise (≤10 h/wk) and had no known personal or family history of hypertension, cardiovascular disorders, and respiratory problems. All subjects were screened for major psychopathology (8). The subjects had not undertaken any shift work or transmeridian travel in the past 3 mo and had no history of sleep problems. They were not experiencing any major life stress and had no examinations scheduled for a few days before, during, or after the study.

The laboratory procedures were approved by the Human Ethics Committee of the University of Melbourne (Australia),