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THE DYNAMICS OF SPINDLES AND EEG SLOW-WAVE ACTIVITY IN NREM SLEEP IN MICE

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INTRODUCTION

In 1960 Michel Jouvet described the occurrence of spindles and slow waves in sleeping cats (12). These hallmarks of sleep, together with the EOG and EMG, provided the basis for the definition of sleep stages in non-human mammals (12, 13). The occurrence of spindles during sleep has been since described in most mammalian species. A comparison of the sleep EEG in mouse strains suggested that their occurrence is determined by genetic factors (28, 29). Neurophysiological mechanisms of spindle oscillations are intimately related to the generation of slow waves (23).

The temporal and spatial dynamics of slow-wave activity (SWA, EEG power between 0.5-4.0 Hz) and spindle activity during sleep could reflect complex regulatory processes. SWA is considered a marker of sleep homeostasis (6, 7), but little is known about the role of spindle activity in sleep regulation.

Spindles are generated within the reticular thalamic nuclei, where neurons typically exhibit a bursting discharge pattern at frequencies of 7-14 Hz in the cat (19) and the rat (15). The ensuing rhythmic hyperpolarisation of thalamocortical neurons leads to rebound spike bursts, which are transferred to the neocortex as spindles (20, 23). Whether thalamocortical bursts occur at delta- or spindle-frequencies depends on the level of membrane hyperpolarisation, which is influenced by activating cholinergic projections from the brainstem and basal forebrain (16, 17, 21). The incompatibility between spindles and delta waves occurs at the level of single neurons, but not necessarily in the EEG (23).

Several studies in humans report an inverse relationship between spindle-frequency activity (SFA, EEG power in the 12-15 Hz range) or spindle density and SWA (27, 2, 9, 31, 3, 14). It was shown that sleep deprivation (SD) not only leads to an increase in SWA, but to a concomitant decrease in SFA (5, 10) and spindle-density (9, 8, 14). A typical U-shaped distribution of SFA or spindle amplitude is observed within NREM sleep episodes (2, 9).

The data obtained in humans are supported by animal studies. In the rat EEG power between 10-25 Hz, increased progressively across the light period, whereas SWA showed an opposite trend (26). Furthermore, SD for 24 hours led to an increase

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