Sleep Medicine 53 (2019) 172–173

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Editorial

Slow wave sleep and steroid hormones

Since Jouvet and Dement's pioneering work in the 1950'-60's, we know that sleep is not a single, inactive state but rather a complex, structured duality between rapid eye movement (REM) sleep and non-rapid eye movement (NREM) sleep [1,2]. Using total, selective, acute and chronic sleep deprivation, the functional role of each sleep stage has been studied for decades.

The hallmark feature of N3 sleep stage, also known as slow-wave sleep (SWS) includes slow waves in the electroencephalogram (EEG), with a frequency of 0.5–2 Hz. They correspond to strong synchronous neuronal activity in the thalamo-cortical loops [3]. Significant studies in the field have shown the central role of SWS in synaptic processes [4], glucose metabolism [5], glymphatic processes [6] and the immune system [7].

Steroid hormones secretion is closely related to the sleep/wake cycle with the majority of the daily testosterone released during sleep in men [8]. Testosterone concentrations increase until the beginning of the first REM sleep episode and remains at that level until awakening [9]. Although many studies have consistently demonstrated that total sleep deprivation lowers testosterone levels [10,11] effects of sleep restriction on testosterone secretion are more nuanced [12,13]. Accordingly, pathological conditions such as fragmented sleep and obstructive sleep apnea are also associated with reduced testosterone levels [14].

Testosterone is a crucial hormone in male sexual behavior and reproduction, but also has important beneficial anabolic effects on muscle mass and strength, adiposity and bone density [15]. Nevertheless, the functional role of different sleep stages in steroid secretion is unclear [16,17]. The hypothesis that SWS suppression changes morning levels of steroids hormones has been addressed directly by Ukraintseva and colleagues [18] in the May 2018 of Sleep Medicine, providing significant novel insights.

Ukraintseva and colleagues' recent study [18], shows that selective SWS suppression by 54.2%, without essential changes in total sleep time, decreased morning testosterone concentrations and 17α-hydroxyprogesterone secretion. In contrast, morning cortisol, DHEA, aldosterone concentrations were unchanged. Their results corroborate cohort study findings which showed that decreased total testosterone levels in men were related to a shorter duration of SWS, a low sleep efficiency and increased nocturnal awakenings and unrelated to their habitual sleep duration [19]. Their study can also explain inconsistencies found in other sleep restriction studies. Therefore, depending on severity of sleep restriction, SWS duration can be decreased, unchanged or even increased leading to contrary results in testosterone levels.

Their results support the hypothesis that SWS duration is more important in testosterone production than total sleep time, however, the mechanisms remain unclear. Indeed, pulsatile luteinizing hormone (LH) release, which stimulates the release of testosterone from the testes, does not seem to be affected by SWS suppression in pubertal children [20] or in sleep restriction in men [21]. In rats, Wu et al., [22] suggested that decreased testosterone during total sleep deprivation may be related to inhibition of the Leydig testicular cells by the neurotransmitter serotonin whose serum concentrations was increased following total sleep deprivation [22]. Interactions between SWS, growth hormone and prolactin could also influence steroidogenesis.

Notably, Ukrainsteva et al., [18] also show that sustained attentional performance was not affected by selective SWS suppression. Many laboratory studies showed that sleep restriction decreases sustained attentional performance while the only sleep stage preserved is SWS [23,24]. These results support the idea that SWS is less involved than N2 sleep stage and REM sleep in sustained attentional performance.

Keeping these significant findings in mind, there are a few limitations and questions regarding Ukraintseva and colleagues' study [18]. As the authors readily acknowledge, one limitation of this study was the partial suppression of SWS duration (by only 54.2%), whereas other studies suppressed SWS by more than 80%. Their objective was to avoid potential stress induced by someone entering in the subject's bedroom. Although experimentally difficult, micro blood sampling across 24 h would allow us to understand the kinetics [17] Finally, the study did not include an active control condition involving the presentation of sounds during sleep when SWS was absent.

Thus, this study provides novel insight on central role of SWS in steroid hormones secretion acutely. The decline in SWS was sufficient to affect the secretion of testosterone and its precursors without changing morning cortisol levels. The crucial role of SWS on an anabolic hormone as testosterone should be kept in mind in muscle recovery or bone healing [25]. Further studies are needed to understand underlying mechanisms.

Conflict of interest

Dr. Pierrick J. Arnal is employee of dreem.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2018.09.012.

DOI of original article: https://doi.org/10.1016/j.sleep.2018.04.012.

https://doi.org/10.1016/j.sleep.2018.09.012

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23 July 2018
Available online 29 September 2018