

# “Neurophysiology of Sleep”

**Article:** “Coupled Electrophysiological, Hemodynamic, & Cerebrospinal Fluid Oscillations in Human Sleep”

**Authors:** Nina E. Fultz et al.

**Source:** *Science* 11/1/2019

## DYNAMICS OF SLEEP:

While REM sleep is typically characterized by dreams & intense neural activity, NREM embodies three stages progressing from a light slumber to a deep sleep. Within NREM, brain activity slows into delta waves and eye & muscle tissues enter a state of relaxation. Participation in NREM promotes the storage of memory, repair of tissue, bone, and muscle growth alongside the strengthening of mental and immune function. Reliance on two mechanisms: influx of cerebrospinal fluid and slow neuronal waves are tied to clearance of metabolic waste and memory consolidation respectively. This study aims to investigate the relationships and patterns between the synchronized slow wave neuronal activity, increased cerebrospinal fluid volume, and cerebrovascular flow during NREM sleep

## SUMMARY

Fultz et al examined the physiological dynamics while the human brain undergoes NREM sleep and provided evidence that suggest coupling of BOLD, CSF inflow, and neural activity. Demonstrated by fMRI at the fourth ventricle, CSF oscillation was matched to delta wave frequency as measured by EEG in NREM sleep (as opposed to the wakeful CSF frequency matching respiration). The measurement of timing, frequency, and wavelength of EEG was related to both hemodynamic patterns and CSF oscillations, with EEG dictating the rate and rhythm of blood flow, which was in turn coupled inversely with CSF. Although predicted values of oscillations were heavily extrapolated with modeling due to the small subject size, identification of these processes encourages the exploration into clinical conditions of sleep - specifically with aging, and disturbances in sleep - as restorative properties have been linked to the metabolic disposal by means of CSF and memory impairment has been associated with diminished hours of NREM sleep.

- Simultaneously measured BOLD signals, fMRI dynamics, EEG, CSF during sleep
  - fMRI at high velocities detect local oxygenated levels (BOLD) & fluid inflow, particularly through the 4th ventricle (CSF)
  - EEG identify brain waves and sleep states (stable wake or NREM)
- Observational Study: researchers cannot directly control the independent variables
- Strength: human subjects, consistent with previous literature on CSF movement & low frequency oscillation of neural activity
- Limitations: small sample size (N = 13; 2 men, 11 women), significant dependence on computer & data manipulation (shuffling)
- Reasoning for co-occurrence of diverse physiological processes & relation to major changes in neural activity & hemodynamics remains uncertain

## THE IMPACT

Although sleep is vital to proper body functions, quality of sleep, as well as amount of time in critical periods of REM & NREM sleep, depreciates as we age and adapt to modern lifestyles leading to serious health implications.

“

“At least 40 million Americans each year suffer from chronic, long-term sleep disorders.”

*American Sleep Association*

“Adults who were short sleepers were more likely to report 10 chronic health conditions compared to those who got enough sleep.”

*Centers for Disease Control & Prevention*

“More than two-thirds of US high school students report getting less than 8 hours of sleep on school nights.”

*Centers for Disease Control & Prevention*

”

SESSION SUMMARIES AND COMMENTARIES WERE GIVEN BY TRANG HAU & CHRISTINA WIRA WITH SUPPORT OF THE PREMED SCENE JOURNAL CLUB

### Additional Sources

1. ASA Authors & Reviewers Sleep Physician at American Sleep Association Reviewers and Writers Board-certified sleep M.D. physicians. “What Is Sleep and Why Is It Important?” American Sleep Association, American Sleep Association, [www.sleepassociation.org/about-sleep/what-is-sleep/](http://www.sleepassociation.org/about-sleep/what-is-sleep/).
2. “CDC - Data and Statistics - Sleep and Sleep Disorders.” Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 2 May 2017, [www.cdc.gov/sleep/data\\_statistics.html](http://www.cdc.gov/sleep/data_statistics.html).
3. Sleep Basics: REM & NREM, Sleep Stages, Good Sleep Habits & More.” Cleveland Clinic, Cleveland Clinic, 7 Dec. 2020, [my.clevelandclinic.org/health/articles/12148-sleep-basics](http://my.clevelandclinic.org/health/articles/12148-sleep-basics).

