

# Impact of Sleep on Extracellular Volume in Human Brains: A Study with Simultaneous Sodium (<sup>23</sup>Na) MRI and EEG

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## Abstract

**Background:** Alzheimer's disease is associated with neurotoxic amyloid-beta (A<sub>β</sub>) plaques. Studies in mice demonstrated that cerebrospinal fluid (CSF) clearance, if impaired, reduces A<sub>β</sub> clearance by 70% and that sleep enhances CSF clearance via expanding extracellular space by 60%. However, the impact of sleep on extracellular volume in human remains unclear due to lack of non-invasive technology. In this study, we use unique sodium (<sup>23</sup>Na) magnetic resonance imaging (MRI) to measure extracellular volume fraction (ECVF) in healthy subjects while monitoring their sleep stage with MRI-compatible electroencephalography (EEG).

**Method:** With IRB approval, we studied 16 cognitively-healthy subjects (age 52.9 ± 17.6 years, ranging 27–77 years, 7 males and 9 females). The study lasted 1.5 hours, including four repeated 16-min sodium MRI on a clinical scanner at 3T (Prisma, Siemens), and continuous EEG recording (Brain Vision, 32-channel, Garner, NC). The subjects were instructed to relax and fall asleep. Sleep was scored to five stages (wake, N1, N2, N3, and REM), based on American Academy of Sleep Medicine (AASM) Manual (v2.6, 2020). Sodium MRI was performed with a dual-tuned (<sup>1</sup>H-<sup>23</sup>Na) birdcage coil (QED, Cleveland, OH) and a custom-developed pulse sequence, twisted projection imaging (TPI), with parameters: FOV= 220mm, matrix size=64, 3D isotropic, TE/TR = 0.5/100ms, flip angle=90°, averages=6, and TA=16min. ECVF,  $\alpha_{ECV}$ , was calculated on the sodium images voxel-by-voxel, i.e.,  $\alpha_{ECV} = \Delta V (a_1 C_{11} + a_2 C_{12}) / \Delta V (145 a_1 + 15 a_2)$ , with  $a_1 + a_2 = 1$ .

**Result:** In panel P1 is the set-up of the study, including the MRI, EEG, sodium images, and hardware set-up. In P2 are typical EEG waveforms and spectra of sleep stages. In P3 is a representative of ECVF maps from a subject (43 years old, female). In P4 are outcomes of the study. Surprisingly, we observed a decrease in ECVF with sleep stage in the gray matter ( $P=0.036$ ) and in the white matter ( $P=0.085$ , nearly significant).

# Sleep Research Volume 20

**Alan F. Stokes, Kirsten Kite**

## Sleep Research Volume 20:

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Doordat ze hun brein onvoldoende kennen doen slimme mensen domme dingen zo stelt neuropsychiater Theo Compernolle In dit baanbrekende boek ontsluit hij in zijn bekende glasheldere stijl de recentste kennis over ons denkende brein en toont hij aan welke breinboeien onze hersenen vandaag in een verstikkende klemgreep houden Maar hij laat ook zien hoe we ze kunnen ontketen en reikt concrete tools en tips aan om het beste uit ons brein te halen Zijn vurige pleidooi voor meer slow thinking in een digitale wereld zal niemand onberoerd laten

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professionals and a comprehensive source book and reference work for researchers The readership includes aviation professionals and researchers including medical personnel and registered Aviation Medical Examiners psychologists and Human Factors specialists training captains senior pilots and engineers air traffic controllers dispatchers and operations staff

Sleep Disorders Chris Idzikowski,2012-03-14 For progress to be maintained in a clinical field like sleep medicine unimpeded unrestricted access to data and the advances in clinical practice should be available The reason why this book is exciting is that it breaks down the barriers to dissemination of information providing scientists physicians researchers and interested individuals with a valuable insight into the latest diverse developments within the study of sleep disorders This book is a collection of chapters which can be viewed as independent units dealing with different aspects and issues connected to sleep disorders having in common that they reflect leading edge ideas reflections and observations The authors take into account the medical and social aspects of sleep related disorders concentrating on different focus groups from

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**Change and Mental Health Equity** Rhonda J. Moore,2024-07-18 Climate change is a driver of poverty poor mental health inequity and increased intersectional vulnerability with significant differential global impacts on individual and community health and well being For example people living in low resource settings in high income countries HICs and in low and middle income countries LMICs are at greater risk often experiencing fragile socioeconomic political and health infrastructures and conflict affected settings FCAS that place them at greater risk and vulnerabilities to climate change related mental health impacts The broad goal of this book is to place a social justice and inclusive lens on climate change and mental health equity focusing on these three key elements people place and community The book includes perspectives from the global North the global South and Indigenous perspectives to help provide greater insight into how we can better understand climate change and mental health equity across peoples place and community This book s three pronged approach will focus on certain trends in this emerging and growing field also bridging some of the more extensive gaps and is a tool for better understanding how mental health disparities might be addressed at this time *An Investigation Into the Effects of Warming and Prostaglandin D2 on Sleep in Rats* Stephen Robert Moriarty,1996 **Artificial Intelligence in**

**Mental Healthcare** Shivan Bhavnani,Ryan McKim,2026-02-24 As the healthcare industry begins to digest recent advances in artificial intelligence AI this book unveils the potential impact of AI on mental and behavioral healthcare It covers existing and potential applications of AI in addition to its main subfields of machine learning generative AI included natural language processing NLP and predictive analytics This book navigates the intricacies of AI in all stages of the patient journey from diagnosis treatment and prevention offering a holistic view of the future of mental and behavioral healthcare It explores how AI is revolutionizing key therapeutic areas within mental health like substance misuse anxiety disorders and mood disorders It also assesses use cases in back office and non patient facing areas including reimbursement processes data collection and management and revenue cycle management Chapters are supplemented with a variety of real world case studies that highlight the practical implications of AI in clinical and non clinical settings This work is relevant for healthcare clinicians innovators researchers healthcare executives and students navigating the intersection of AI and mental and behavioral healthcare **Annual Report** Brain Research Institute, University of California, Los Angeles,University of California, Los

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Sleepless Annabel Abbs,2024-01-18 Sleepless has changed how I feel about sleep I was captivated The Times Book of the Week This book will inspire you to get up light a candle and experience your own Night Self Financial Times An antidote to sleep zealotry New Scientist THE NIGHT SELF IS CREATIVE CURIOUS VULNERABLE ENCHANTED COURAGEOUS In the winter of 2020 Annabel Abbs experienced a series of bereavements As she grieved she kept busy by day but at night sleep eluded her And yet her sleeplessness led to a profound and unexpected discovery her Night Self As the night transformed into a place of creativity and liberation Annabel found she wasn't alone From the radical fifteenth century philosopher Laura Cereta and subversive artist Louise Bourgeois to Virginia Woolf and the activist Peace Pilgrim women have long found sanctuary inspiration and courage in darkness Drawing on the latest science which shows we are more imaginative open minded and reflective at night Annabel set out to discover the potential of her Night Self Sleepless follows her journey from midnight hikes to starlit swims from Singapore the brightest city on Earth to the darkest corner of the Arctic Circle and finally to that most elusive of places sleep A moving revelatory voyage into the dark Sleepless invites us to feel less anxious about our sleep and to embrace the possibilities of the night

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