Sleep Spectral Alterations and Microarchitecture Disruptions in Ischemic Stroke: A Whole Night Polysomnography Study

Mythirayee S [1], Srijithesh P. R [1], Ravi Yadav [1], Doniparthi Venkata Seshagiri [1], Ravindra PN [2], Jitender Saini [3], Bindu Kutty[2]

[1]Department of Neurology, National Institute of Mental Health and Neurosciences (NIMHANS, Bengaluru, India; [2]Department of Neurophysiology, Centre for Consciousness Studies, National Institute of Mental Health and Neurosciences (NIMHANS, Bengaluru, India; [3]Department of NIIR, National Institute of Mental Health and Neurosciences (NIMHANS, Bengaluru, India

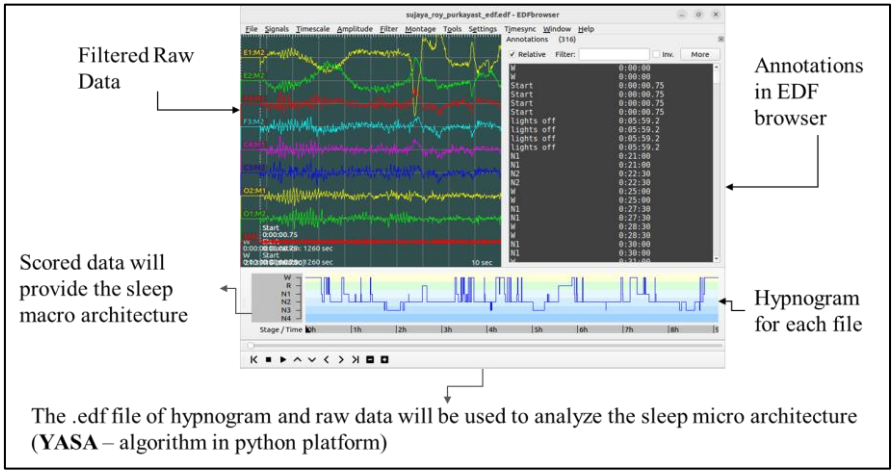
Background:

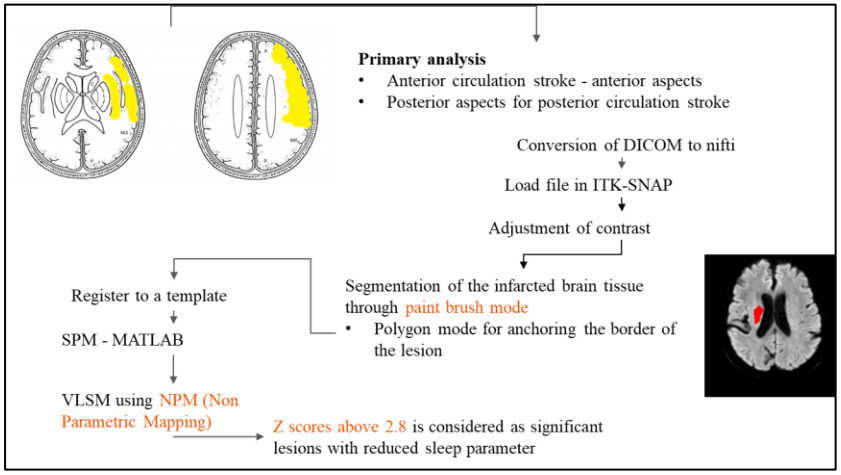
- Sleep microarchitecture, including spindles, K-complexes, and slow waves, plays a critical role in neuroplasticity and recovery.
- However, alterations in these features following stroke remain underexplored.

Aim: To investigate detailed sleep microarchitecture and EEG spectral changes in ischemic stroke patients during the subacute phase, compared to age- and sex-matched healthy controls using whole-night polysomnography.

Methodology:

- 30 ischemic stroke patients (≤1 month & 30age/sex-matched controls
- - Overnight polysomnography (32-channelPSG
- - Sleep EEG scored using AASM 2023
- - Microarchitecture analyzed with YASA toolbox
- - Spindles (density, amplitude, duration, slowwaves, REM spectral power assessed
- Cycle wise analysis (2 cycles)
- Spindle density was further correlated with the lesion





Results:

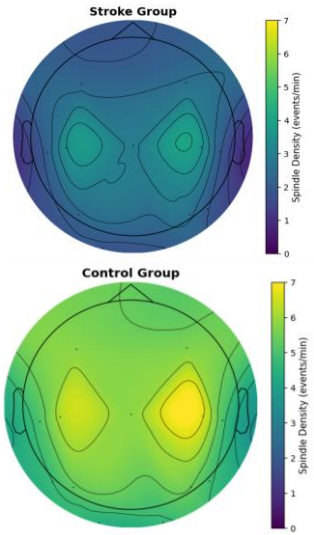
- Thirty ischemic stroke patients (mean age: 51.4 ± 10.2 years; 66.6% male and 30 healthy controls (mean age: 50.8 ± 9.6 years; 66.6% male completed overnight PSG.

	Stroke patients (N=30)	Controls (N=30)	P-value
Age in years (Mean(SD:SD)	50.4 (SD: 12.5)	53.6 (11.3)	0.29
Sex (males %)*	66.6% (n=20)	66.6% (n=20)	0.06
Time of onset of stroke and date of Polysomnography (Duration in days)	21.5 (SD: 8.6)	------	
Risk factors (%)			
Diabetes mellitus	48	40	0.62
Systemic hypertension	37.7	26.5	0.29
Alcoholism	33.3	10	0.18
Smoking	30.3	20	0.26
ASSIST Score	11.5 (2.2, 16)	2(1,7.7)	0.003
Stroke Assessment Scales (Mean(SD:SD), [Median (Q1, Q3)]			
Modified Rankin Scale	1 (0, 3)	NA	
NIH Stroke Scale	4 (0,8)	NA	
Barthel Score	81.8 (SD: 23.9)	NA	
Relevant Anthropometry (Mean(SD:SD)			
BMI (kg/m2)	27.5 (SD:5.7)	26 (SD: 5.46)	0.28
Neck circumference (cm)	36.9 (SD: 7.4)	37 (SD: 6.5)	0.95
Abdomen circumference(cm)	103.3 (SD: 12.6)	102 (SD:12.7)	0.68

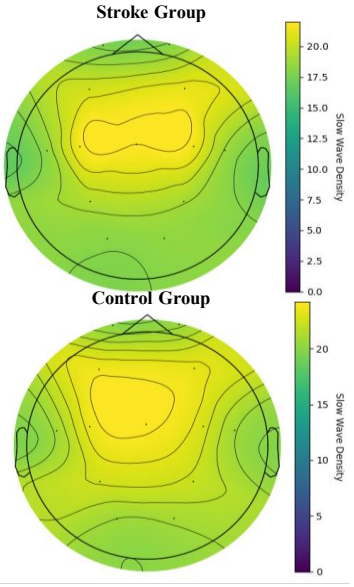
* 1 female patient and 1 control was included who were in their Menopause

Region	Ischemic Stroke (n=30)	Health Volunteer (n=30)	Independent sample t test (p-value)
Spindle Density			
F3	2.89 (1.12)	5.76 (2.04)	< 0.01
F4	2.76 (0.89)	5.66 (2.2)	0.008
C3	3.12 (1.34)	6.17 (1.95)	< 0.001
C4	3.67 (1.49)	6.62 (2.06)	< 0.001
Avg Amplitude			
F3	15.6 (2.12)	18.1 (0.805)	< .001
F4	16.0 (2.75)	19.5 (1.1)	< .001
C3	13.8 (0.192)	14.1 (0.283)	< .001
C4	14.2 (0.411)	14.9 (0.378)	< .001
Avg Frequency			
F3	11.5 (0.0912)	12.002 (0.804)	0.324
F4	10.8 (0.674)	12.1 (0.266)	< .001
C3	10.9 (0.206)	13.6 (0.162)	< .001
C4	11.9 (0.129)	15.5 (0.213)	< .001
Duration			
F3	1.50 (0.070)	1.56 (0.222)	0.043
F4	1.35 (0.15)	1.65 (0.193)	< .001
C3	1.70 (0.129)	1.80 (0.030)	0.006
C4	1.53 (0.148)	2.25 (0.240)	< .001

EEG Topographic Maps of Sleep Spindle Density During N2 Sleep



EEG Topographic Maps of Slow Wave Density During N3 Sleep



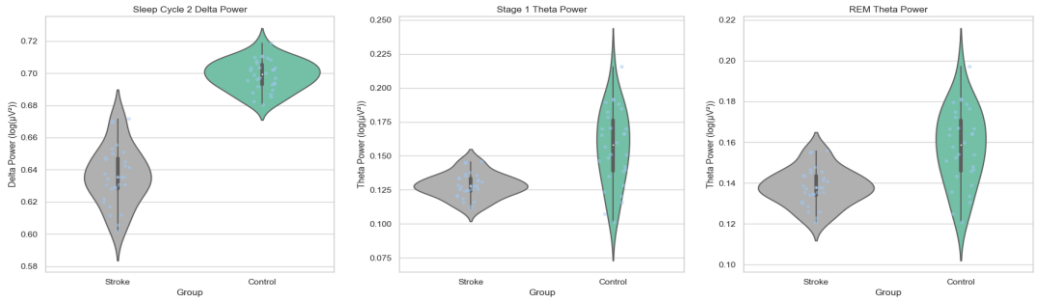
K-Complex Characteristics	Stroke patients (n=30)	Control (n=30)	P value	95% Confidence Interval (LL,UL)
Number of K Complex in stage 2 C3:M2	28.4 (SD: 3.12)	37.9(SD:3.95)	< .001	(27.28, 39.31)
K complex stage 2 duration (msec) C3:M2	675 (SD: 68.2)	863(SD:54.3)	< .001	(650.59, 882.43)
K complex stage 2 average Amplitude (uV) C3:M2	85.2 (SD: 9.8)	115(SD:8.75)	< .001	(81.69, 118.13)
Number of K Complex in stage 2 F3:M2	45.6 (SD: 3.15)	55.8(SD:4.19)	< .001	(44.47, 57.60)
K complex stage 2 duration (msec) F3:M2	635 (SD: 73.0)	837(SD:56.1)	< .001	(608.88, 857.08)
K complex stage 2 average Amplitude (uV) F3:A2	97.4 (SD: 11.2)	128(SD:8.03)	< .001	(93.39, 130.87)

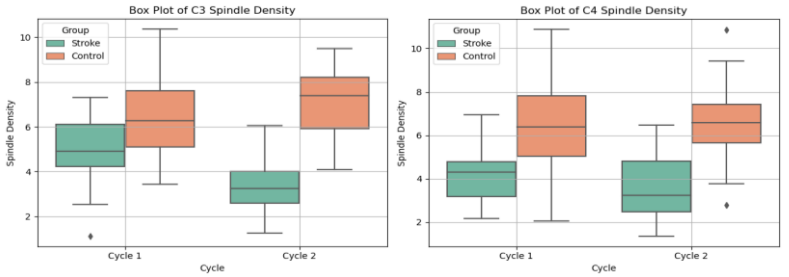
- In N3 sleep, stroke patients had reduced slow-wave amplitude (**59.2 µV vs. 78.5 µV; p = 0.01** and a shallower slope (**−1.47 µV/ms vs. −2.18 µV/ms; p = 0.01**)

- REM density was lower in stroke patients (**1.9/min vs. 2.6/min**), though not statistically significant (p = 0.07)

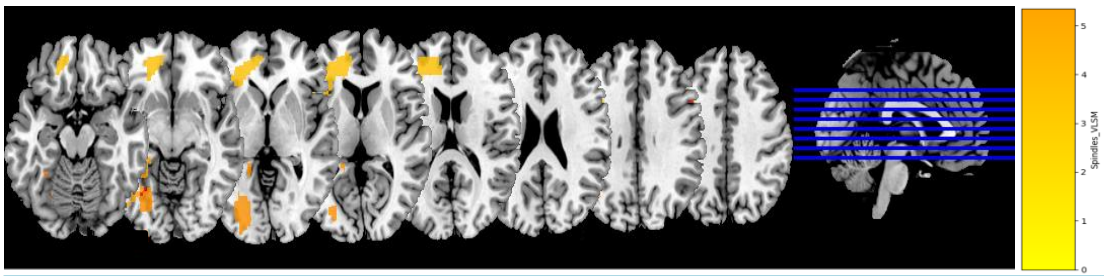
- Spectral analysis showed significantly reduced theta ($p = 0.03$) and alpha ($p = 0.018$) power in the stroke group. In addition, delta power during Cycle 2 was significantly lower in stroke patients (**0.64 ± 0.02 vs. 0.70 ± 0.01; p = 0.045**)

Group	Stage/Cycle	Delta			Theta			Alpha			Beta		
		Stroke	Control	P value	Stroke	Control	P value	Stroke	Control	P value	Stroke	Control	P value
Sleep Stages	Stage 1				0.14 ± 0.01	0.16 ± 0.01	0.04	0.07 ± 0.01	0.07 ± 0.02	0.342	0.04 ± 0.01	0.02 ± 0.01	0.47
Sleep Stages	Stage 2	0.71 ± 0.01	0.67 ± 0.01	0.583	0.13 ± 0.01	0.14 ± 0.01	0.127				0.03 ± 0.01	0.02 ± 0.01	0.385
Sleep Stages	Stage 3	0.69 ± 0.02	0.66 ± 0.02	0.203	0.15 ± 0.03	0.17 ± 0.04	0.144				0.03 ± 0.01	0.03 ± 0.01	0.446
Sleep Stages	REM				0.13 ± 0.01	0.16 ± 0.02	0.03	0.08 ± 0.01	0.06 ± 0.02	0.018	0.06 ± 0.01	0.04 ± 0.01	0.437
Sleep Cycles	Cycle 1	0.69 ± 0.02	0.67 ± 0.02	0.539	0.13 ± 0.01	0.14 ± 0.018	0.192	0.06 ± 0.02	0.07 ± 0.02	0.081	0.03 ± 0.01	0.04 ± 0.01	0.496
Sleep Cycles	Cycle 2	0.64 ± 0.02	0.70 ± 0.01	0.045	0.14 ± 0.01	0.15 ± 0.03	0.189	0.07 ± 0.01	0.08 ± 0.02	0.07	0.04 ± 0.01	0.03 ± 0.01	0.541





Voxel-based lesion-symptom mapping



- Significant clusters for reduced spindle density found in: Right inferior frontal gyrus, Right dorsolateral prefrontal cortex, Left inferior parietal lobule, Right middle temporal gyrus, Left insula
- Indicates spindle-related impairments are linked to frontal and temporoparietal lesions.

Conclusion: This study reveals that ischemic stroke significantly disrupts sleep microarchitecture, including spindle activity, K-complex generation, slow-wave patterns, and REM spectral features. These findings support the role of sleep EEG markers as potential tools for monitoring and guiding post-stroke recovery.

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Acknowledgement: This work was supported by the Indian Council of Medical Research (ICMR) Senior Research Fellowship, Government of India. I acknowledge the contributions of the sleep lab staff and my colleagues for their assistance in data collection and analysis.