Stationarity during REM sleep in Old Adults

Alejandra Rosales-Lagarde, PhD[1,2], Erika Rodríguez-Torres, PhD[3], Julio Enciso-Alva, BS Student[3], Claudia Martínez-Alcalá, PhD[1,2], Génesis Vázquez-Tagle, MD Student[1], Margarita Tetlalmatzi-Montiel, MD[3], Jorge Viveros, PhD[3], and **José Sócrates López-Noguerola**, PhD Student[1,4]

(1) Universidad Autónoma del Estado de Hidalgo, San Agustín Tlaxiaca, Mexico (2) Consejo Nacional de Ciencia y Tecnología, Mexico, Mexico (3) Universidad Autónoma del Estado de Hidalgo, Pachuca, Mexico, (4) University of Medicine, Göttingen, Germany

Introduction

Rapid Eye Movement (REM) sleep exhibits low voltage, mixed frequencies, muscular atonia and REMs [4]. When quantitative analyses of the signals are carried out, usually, non-linearity and non-stationarity are assumed without an adequate analysis, especially in Old Adults (OA). The aim of this research was to compare the proportion of stationarity of REM sleep vs non-REM (NREM) sleep and wakefullness (W) using the Priestley-Subba Rao (PSR) test. We also explore if this tool can be used to detect the traditional indicators of sleep stages along the sleep recording, focusing especially in REMs of REM sleep.

Methods - Subjects

Five Old Adults (OA) [age: 68.2 ± 7.2; education: 9.2 ± 2.7] without depression neither anxiety and with intact daily living activities were selected. Also, evaluations with the Mini-Mental State Examination (MMSE, 29.4 ± 0.9) and a one night polysomnography were performed. 30 second epochs were classified according to the AASM and every epoch of W, NREM and REM sleep was filtered by STL algorithm [1] and then subjected to PSR test (below).

Priestley-Subba Rao (PSR) test

The test introduced by Priestley and Subba Rao to detect non-stationarity [2,3], estimates the spectral density function (SDF) and then tests the hypothesis "SDF does vary over time" –which is equivalent to nonstationarity.

Percentages of stationary epochs were calculated with respect to each stage, and Wilcoxon t-tests were used to compare them.

Figure 1: Diagram of the method. PSG of one 30 s epoch, for one OA (Left). REM sleep is detected by AASM standards and weak stationarity is detected using PSR test (Center). Comparison of percentaje of stationary epochs at REM (green) and NREM (black), for one OA (Right).

Results

Figure 2: Distribution of stationary epochs (black) over time, for one OA. REM sleep is shown in green.

Figure 3: Mean ± 1 standar deviation (Left), for the percentage of stationary epochs calculated over REM and NREM sleep. Asterisc represent significative differences found using paired one-tailed Wilcoxon t-test. Diagram representing the zones where significant differences were found (Right).

The PSR test effectively showed different proportions of stationary epochs, accoring to the classification of REM sleep stages in each subject. In Figure 2, for one OA, stationary epochs are shown in black and the classification of REM sleep is shown in green. Clearly, a lower proportion of stationarity was found in REM sleep vs the other stages. These differences reached significance in C3, C4, CZ, F7, Fp1, LOG, ROG ($p<0.05$, Figure 3)

Figure 4: Distribution of stationary epochs for all 5 subjects, highlighting the found pattern which is asociable with REM sleep. (Up) Epochs corresponding to the full-night recordings. (Down) Zoom over the patterns, highlighting details of them: a 'block of stationarity' [red] a 'blank' [blue] and a block containing REM sleep [green]

Conclusions

In Old Adults, REM sleep showed lower proportions of epochs with weak stationarity compared to W and NREM sleep at anterior areas, a result that could be explained by the tonic and phasic REM sleep.

The graphic method described seems to be a suitable way to detect REM sleep in OA.

Aknowledgements

This study was partially supported by the following: SNI-CONACYT (96080) to ERT; PROMEP Convenio UAEHGO-103.5-14-10567, the Mexican Mathematical Society Sofia Kovalévskaya (2014) to ERT and the support of Academicians Applied Mathematics to Biology and Computer Science to ERT

References

[1] R. B. Cleveland, W. S. Cleveland, J. E. McRae, I. Terpenning. STL: A seasonal-trend decomposition procedure based on loess. Journal of Official Statistics, 6:3–73, 1990.

[2] M. B. Priestley. Spectral Analysis and Time Series, volume 1,2. Academic Press,1981.

[3] M. B. Priestley and T. S. Rao. A test for non-stationarity of time-series. Journal of the Royal Statistical Society: Series B (Methodological), 1(31):140–149, 1969.

[4] Rosales-Lagarde A., Yolanda-del-Río-Portilla I., Guevara M., Corsi-Cabrera M. Caída abrupta del tono muscular al entrar a sueño MOR en el ser humano. Salud Mental. 2009; 32(2): 117–123