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Human Brain Signal Analysis: Juvenile Myoclonic Epilepsy Diagnosis by Electroencephalograph

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ABSTRACT

Juvenile Myoclonic Epilepsy recognition and its cognitive effect were investigated through Welch Periodogram analysis of EEG signals. The micro-volt brain delicate signals were measured by our laboratory KL-720 system with Kl-75004 Electroencephalogram module, after careful adjustments. The digital signal processing DSP proved itself through the MATLAB software as useful analyzing tool for the absolute and relative power extracted from EEG power spectrum in different frequency bands. It was the standard method by which Juvenile Myoclonic Epilepsy detected in primarily stage where effective treatment is available. It also indicated that the Juvenile Myoclonic Epilepsy have not any effect on brain cognitive function.

Keywords : Electroencephalogram, Juvenile Myoclonic Epilepsy, Digital Signal Processing, Power Spectrum Analysis, Welch Periodogram, Absolute Power, Relative Power

I. INTRODUCTION

Juvenile Myoclonic Epilepsy (JME) was reported as a probable case in 1867 [1]. Myoclonic epilepsy of adolescence and benign myoclonic juvenile epilepsy are other terms have been used to define this condition [2].The term "juvenile myoclonic epilepsy" was proposed in 1975[3] and has been adopted by the International League Against Epilepsy (ILAE).[4]

This disease, which depends on patient family history, occurs from 6 through 22 years of age, and affected patients present with myoclonic jerks, often associated with generalized tonic-clonic seizures and absence seizures. JME is non-progressive, and there are no abnormalities on clinical examination or intellectual deficits. Psychiatric disorders may coexist [5].

JME Diagnosis depends on data obtained during clinical criteria or on electroencephalographic findings like Myoclonic Jerks, Absence Seizure (AS), and Generalized tonic clonic (GTC) or Grand mal seizure and spikes or Poly-spikes on EEG waveform.Usual neuroimaging studies show no abnormalities [6].This clinical presentation is quite characteristic, but misdiagnosis and its attendant treatment delay are frequent [7].

In a previous study, the correct diagnosis of JME was performed after delay for 8.3+/-5.5 years after 6+/-4 clinic visit [6]. The most incorrect diagnosis is GTCS as a parital epilepsies [8] .there are different factors (clinical, Electroencephalogram) contributing these errors [9].

Failure in myoclonic jerks detection is one of errors occur in clinical examination also most of patients do not complain from myoclonias [6] as they find them unimportant symptom or being ashamed by their occurrence, in addition that the myoclonic seizures are uncommon symptoms and not perceived as abnormal [9] that make patients interpret them in different ways, and many believe they are part of a GTCS [9].

Another reason of clinical errors that the clinicians frequently fail to ask about the occurrence of myoclonias

during medical interview, until now most of physicians have no familiarity with the JME disease ; therefore they interpret myoclonic jerks as stress or partial epileptic seizures [9].

Another factor of diagnosis errors occurs in electroencephalographic like the presence of findings that are atypical but do not exclude JME [6]. Asymmetry of the recording amplitude with a generalized pattern also leads to diagnosis errors, this criteria had happen with 38 patients out of 76 [8].

Correct diagnosis of JME has an important effect on the treatment and patient recovery [6]. Delay in disease diagnosis may cause a status epilepticus, nonreversible brain damage, social difficulties, and even death [6].

In our research, Engineering methods and tools was very helpful in Juvenile Myoclonic Epilepsy recognition and its effect on cognitive functions, using welch Periodogram analysis as a digital signal processing (DSP) method, the changes in the level of cognitive functions attributable to Juvenile Myoclonic Epilepsy malformation were indexed by changes in absolute and relative power occurring in the conventional frequency bands across the EEG frequency spectrum of 4-30 HZ.

II. METHODS AND MATERIAL

A. The Electroencephalograph:

Brain waves can be roughly defined as the mean electrical activity of brain cells [10]; these waves can be measured from cerebral cortex [11] with electronic devices such as the Electroencephalogram (EEG) which can be used for diagnosing psychological disorders. Our recent focus is on Juvenile Myoclonic Epilepsy diagnosis and its cognitive function.

Brain waves magnitudes and frequencies changes are based on the electrical activity of neurons and are related to changes of states of conscience (concentration, relaxation, meditation, etc.). Every human being has its own characteristics in their brain activity. This activity has a pattern and a rhythm-and incorporates the frequencies ranges, delta, theta, alpha beta and gamma on several levels due to various daily activities undertaken by each individual [12, 13].

EEG analysis is not the only test carried out, investigation with other tests such as MEG, PET, and MRI, may be used to correctly validate the findings of the EEG analysis [14].

B. EEG Acquisition System using KL-720 with KL-75004 module:

According to the characteristics of EEG which are, signal amplitude range from 1 to 100 micro volt and frequency range from 0.5 to 100 HZ. The acquired signal affected by several interference sources like eye potentials (EOG, ERG), ECG, Electrode artifacts and muscle activity [15]. These factors affect the signal and may shift the mean value of the signal.

A signal acquisition system was designed to capture the wanted brain signals using surface electrode. One of the main units in this system is an instrumentation amplifier with a gain of 50 is used as the preamplifier for picking up the unipolar component of EEG signals, then the band-reject filter is used to minimize the unwanted interferences mentioned above. Other unit of the system is the isolation circuit used to isolate the signal from the line power source; which was implemented with voltage transformer. Also the band width of the band-pass filter is from 1 to 20 Hz, and the amplifier with an amplification factor of 1000(max) can magnify the week signal that passes through the filter. Then the amplified EEG signals can directly send to a laptop with KL-720 software for display.

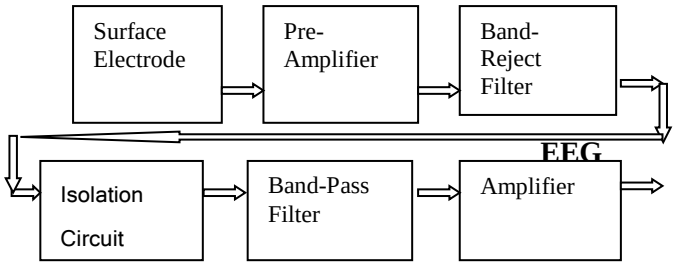

Figure 1 : Block diagram of EEG measurement Circuit.

EEG Module KL-720 had been very carefully adjusted to obtain the accurate EEG signals and suppressing the noise. Extra care and efforts done to correctly calibrate the Preamplifier and the filters used in the system. , low pass filter, amplifier characteristics measurements had been executed to obtain the accurate signals.

Our designed signal system has a vital improvement which simplifies too much the measurements process and comfort the patient or person under test. The 25 electrode hat or the 101 electrode hat is replaced with only three dry electrodes. See figure 3. This simple construction led to powerful results. Two of the three EEG electrodes

(bipolar mode) placed on the frontal, occipital lobe to record EEG signal and the third is the reference electrode at the ear lobe as the reference potential [16].

Figure 2 : Measuring EEG signal using three EEG Electrodes.

C **Juvenile Myoclonic Epilepsy EEG waveform:**

When an EEG waveform is recorded for a patient who has Juvenile myoclonic epilepsy, a signal with recent onset GTCS and myoclonic jerks was produced. EEG shows generalized, irregular, 3.5HZ spike and wave and poly-spike and wave complexes. Because of difficulty of getting the signal from juvenile myoclonic epilepsy patient, the signals obtained from a previous research titled by juvenile myoclonic epilepsy by Dr.Marcio Moacyr Vasconcelos. [5]

D Normal EEG waveform:

The normal EEG signal was recorded under conditions of a wake and at rest with closed eyes, a wave about 1 Hz in frequency and 100 microvolts in amplitude is generated from the occipital region. Obtained signal called alpha wave and considered as a standard wave of a normal patient.

Data Collection and processing:

Engage Digitizer program is used to export data from the EEG waveforms having the Juvenile Myoclonic Epilepsy to an Excel file and then to Matlab program for analysis and decision make as follows:

Transform the EEG signal charts to images with suitable readable extension. Careful image aligned to the origin point is done using axis point tool. Next the image been manipulated with the software. The curve point tool exports the largest number possible of EEG curve points to an abnorm1 with the required extension (CSV, XLS and TXT). The file is loaded to the MATLAB program for further processing and drawings. The resultant adequately enlarged EEG signal is produced with a percentage error less than or equal to +/- (0.5-2) microvolt as shown in figure(4,5) where the resultant EEG signals for both normal and Juvenile Myoclonic Epilepsy pathologic cases are drawn.

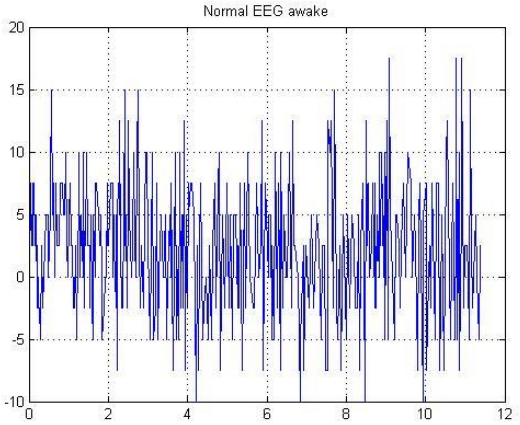

Figure 3: Normal EEG waveform.

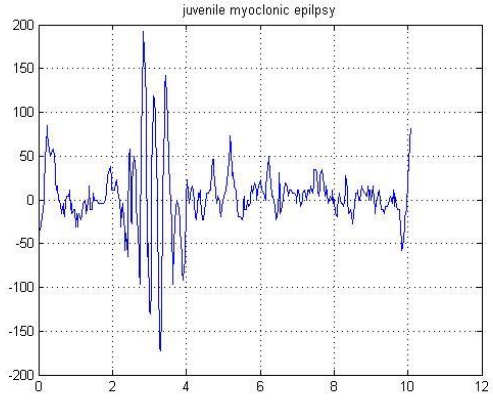

Figure 4: Juvenile Myoclonic Epilepsy waveform.

The EEG signals are digitized at 64 samples / second. Digitized records were then subjected to compensation for linear trend and data tapering by a Hanning window and then analyzed by FFT. Power spectrum derived from Welch Periodogram analysis for each EEG signals extracts values of absolute and relative power (proportion of power across 4-30 HZ) in 5 frequency bands: 4-7.75 HZ (Theta), 8-9.75 HZ (Alpha1), 10-13 HZ (Alpha2), 13.25-19.75 HZ (Beta 1) and 20-30 HZ (Beta 2). These bands were based on those defined by Cooper et al. (1980) [18], with further sub-division of the alpha and beta bands [17].

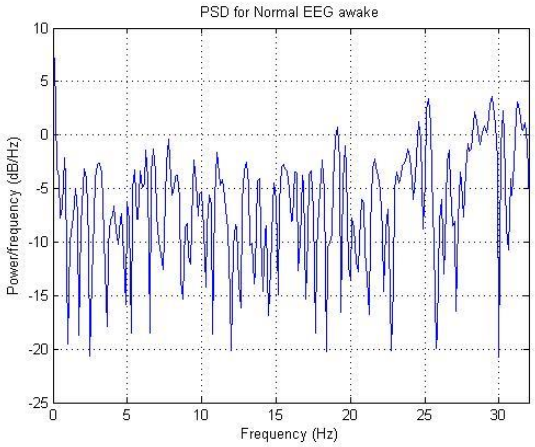

Figure 5: Power spectrum density for Normal EEG Signal.

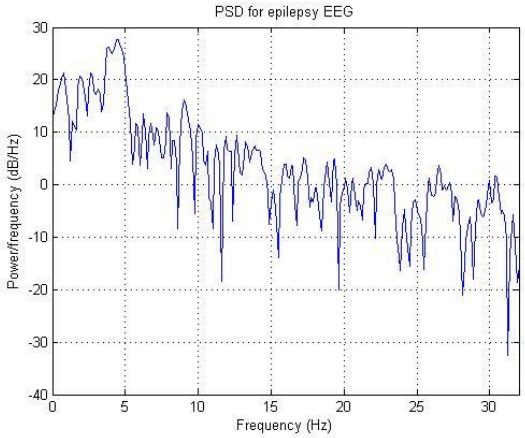

Figure 6 : Power spectrum density for juvenile myoclonic epilepsy Signal.

III. RESULT AND DISCUSSION

As shown in figure (7), we observed that Juvenile Myoclonic Epilepsy have a significant main effect in total absolute power. Absolute power for bands theta to beta 1 (4-19.75) following Juvenile Myoclonic Epilepsy EEG signal are greater than values of normal EEG Signal , But for Beta2 band absolute power of Juvenile Myoclonic Epilepsy EEG signal is almost equal the normal condition of EEG signal.

Absolute Power ln (microvolt^2)

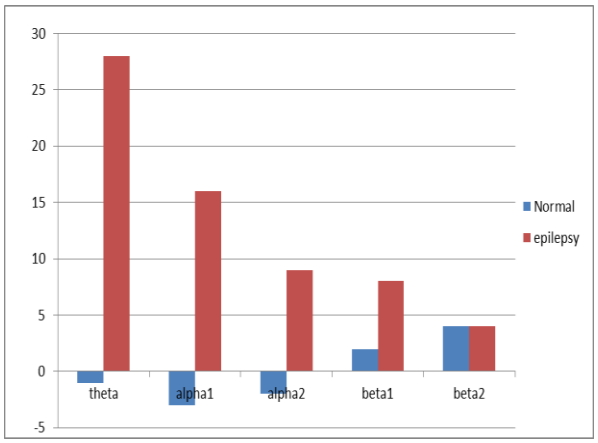

Figure 7: Main effects of Juvenile Myoclonic Epilepsy on absolute power in each frequency band.

For relative power (fig. 8), significant main effects of Juvenile Myoclonic Epilepsy were manifest as decreasing in values of relative power in bands from theta to beta1 bands (4-19.75) and no effect for beta2 band.

Relative Power(x) as ln (x/1-x)

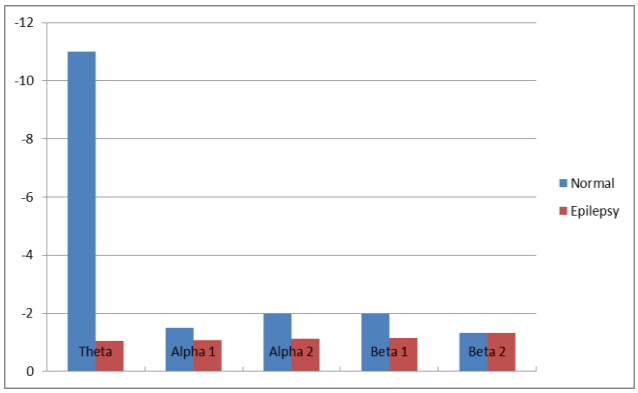

Figure 8: Main effects of Juvenile Myoclonic Epilepsy on relative power in each frequency band.

IV. CONCLUSION

The practical EEG measurements process made easier and simpler by using the three dry electrodes, replacing the used 25 electrodes hat or the 101 electrodes hat.

This research results assured that Juvenile Myoclonic Epilepsy could be reliably diagnosed via EEG which is more economic and comfortable to patient than the MRI and can avoid clinical diagnosis also EEG virtual detecting characteristics.

From engineering point of view parameters like values of relative and absolute power extracted from EEG power spectrum by DSP through the MATLAB by comparing normal and pathological cases would quantitavily be able to identify the Juvenile Myoclonic Epilepsy malformation. For instance:

- Values of relative and absolute power extracted from EEG power spectrum Showed that Juvenile Myoclonic Epilepsy can be diagnosed as

increasing in absolute power values in bands from alpha1 to beta1 and almost equal for beta2, also for relative power as decreasing in power bands from theta to beta1 bands and equality in beta2 band.

- For this current research the result show that the Juvenile Myoclonic Epilepsy has no effect on Beta 2 signal which concerned with high cognitive function so there is no significant evidence that the Juvenile Myoclonic Epilepsy is the culprit of brain cognitive problems.

So, the engineering method represented here based on Welch Periodogram would open a new easy and fast method for brain diseases identification in early stage where effective treatment is available

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