Research Article
Quantification of Myosignal Parameters in HD Patients

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Abstract: Developments in signal processing techniques, has made possible extraction of useful inside information from diseased myosignals through surface Electromyography (sEMG). This study attempts to quantify the myosignal parameter of Hansen's Disease (HD) patients. The EMG signals acquired from the Abductor Digiti Minimi (ADM) muscle were analyzed using time, frequency domain and wavelet techniques *vis à vis* healthy subjects. Quantifying the myosignals of the diseased-probably attempted for the first time-will help the physician in early diagnosis. Interestingly the test results show drastic deviation between the two. Its development and implementation will save the subjects from developing deformity.

Keywords: EMG, leprosy, quantification, time and frequency domain analysis

INTRODUCTION

Hansen Disease is a nonfatal, chronic infectious disease caused by *Mycobacterium leprae*, whose clinical manifestations are largely confined to the skin, peripheral nervous system, upper respiratory tract, eyes and testes (Central Leprosy Division, 2013; Tony, 2007). A total of 1.27 lakh new cases were detected during the year 2012-13, which gives annual new case detection rate of 10.35 per 100,000 populations. A total of 3865 grade 2 disability detected in the new leprosy cases during 2012-13, which gives the grade 2 disability rate of 3.14/million population. A total of 0.83 lakh cases are on record as on 1st April 2013, giving a prevalence rate of 0.68 per 100,000 populations. The above statistics portrays that though the target of elimination was ostensibly achieved in most parts of India, new cases are still being diagnosed (Central Leprosy Division, 2013).

'Early detection improves prognosis' is a general axiom in medicine whereas in leprosy delay in detection is strongly associated with an increased risk of irreversible neural impairment (Wim *et al*., 2008; Vivekanandan *et al*., 2013a). A survey of relevant literature shows that the electro diagnostic tests in HD are mostly confined to the evaluation of the motor and sensory Nerve Conduction Velocity (NCV). The NCV test suffers from the fact that there is a wide variation in its value even among the healthy. Since leprosy affects the nerves first which leads to muscular deficiency, myosignals should be the first candidate for detecting the disease (Sumit *et al*., 2013; Emmanuel, 1988). Prasad *et al*. (1996) had developed a microprocessor based EMG analysis system and demonstrated that Electromyography (EMG) will be useful to clinicians for enhancing the understanding of a patient's dynamic performance.

The EMG signal can be readily analyzed and the constants extracted to differentiate a suspected leprosy patient from the healthy. EMG signal allows observation of overall muscular activity during specific functions, which is a desirable addition to our database (Carlos, 1990, 1992; Lineu *et al*., 1999).

MATERIALS AND METHODS

This pilot study covered 30 patients consisting of multibacillary category with a treatment of five months as well as a freshly diagnosed one. The study was carried in Thiruvannamalai Government hospital, Tamil Nadu-India which spanned a period of 2 months from July to September 2013.

Study subjects: There were six females (20%) and twenty four males (80%) in the age group of 16 to 60 years (mean 41.5 years). Out of the 30 cases, four females were students and the other two house wives and all the males (24) were laborers. Informed consent was taken from all the patients before they were subjected to clinical examination. After a thorough cutaneous and neural assessment, the electrophysiological study was done with CMC DAQ machine from Christian Medical College, Vellore, Tamil Nadu-India. CMC DAQ is a suite of software and associated hardware for data acquisition, experiment control and data processing. Filters were set at 2-5 Hz and sweep speed was 2 ms per division and it is recorded for duration of 10 sec. All the subjects

involved in this study had registered for MDT and were smear positive, each having four or more skin lesions and involvement of nerve thickening. The freshly diagnosed patient had no lesions but was smear positive.

Region under study: Since *Myobacterium leprae's* predilection for ulnar nerve is well known, the study was confined to that and it's associated Abductor Digiti Minimi (ADM) muscle which plays an important role in the movement of fingers, for grasping objects. Ulnar neuropathies often result in progressive weakness or even wasting of muscles (Vivekanandan *et al.*, 2013a, 2012). It is also the most affected nerve where severe damage leads to clawing of fingers. Hence quantifying the EMG signal acquired from the ADM muscle will be of tremendous use in the early diagnosis of neuromuscular disorders. Two disc electrodes of diameter 1.5 cm were deployed and kept at a distance of 3 cm in ADM muscle with a reference electrode.

Sampling and study size: The sample size calculation was based on hypothesis test with a confidence level of 95% and margin of error as 15 for a targeted population as 100, the sample size is calculated as 30.

RESULT ANALYSIS

Subjecting the myosignal directly to digital signal processing and wavelet toolkit in MATLAB leads to

Table 1: Comparisons between healthy and diseased

Age (years)	Parameter	Isotonic		
		Healthy (average)	HD patient (approximate)	HD patient (average)
15-25	MRV (μV)	40-36	3.30	>30
	RMS (μV)	45-40	3.80	>25
	MF (Hz)	60-50	83.33	<70
26-35	MRV (μV)	35-32	8.20	>26
	RMS (μV)	40-35	14.40	>20
	MF (Hz)	50-35	101.00	<65
36-45	MRV (μV)	25-22	7.17	>16
	RMS (μV)	30-25	11.90	>15
	MF (Hz)	45-30	65.50	<55
46-55	MRV (μV)	22-18	9.81	>12
	RMS (μV)	25-22	10.63	>14
	MF (Hz)	30-25	55.01	<45

Table 2: Percentage variation

Age group	MRV (%)	RMS (%)	Median frequency (%)
15-25	90.8	90.5	40
26-35	75.0	61.0	50
36-45	72.0	46.0	28
46-55	38.0	53.0	66

extraction of parameters. The Myoelectric signals were recorded under isotonic conditions which would be easy to implement in the field settings and the quality is also not compromised. Correlating the data of healthy (Vivekanandan *et al.*, 2013b) with the status of the disease as observed through other clinical parameters will pave the way for early diagnosis.

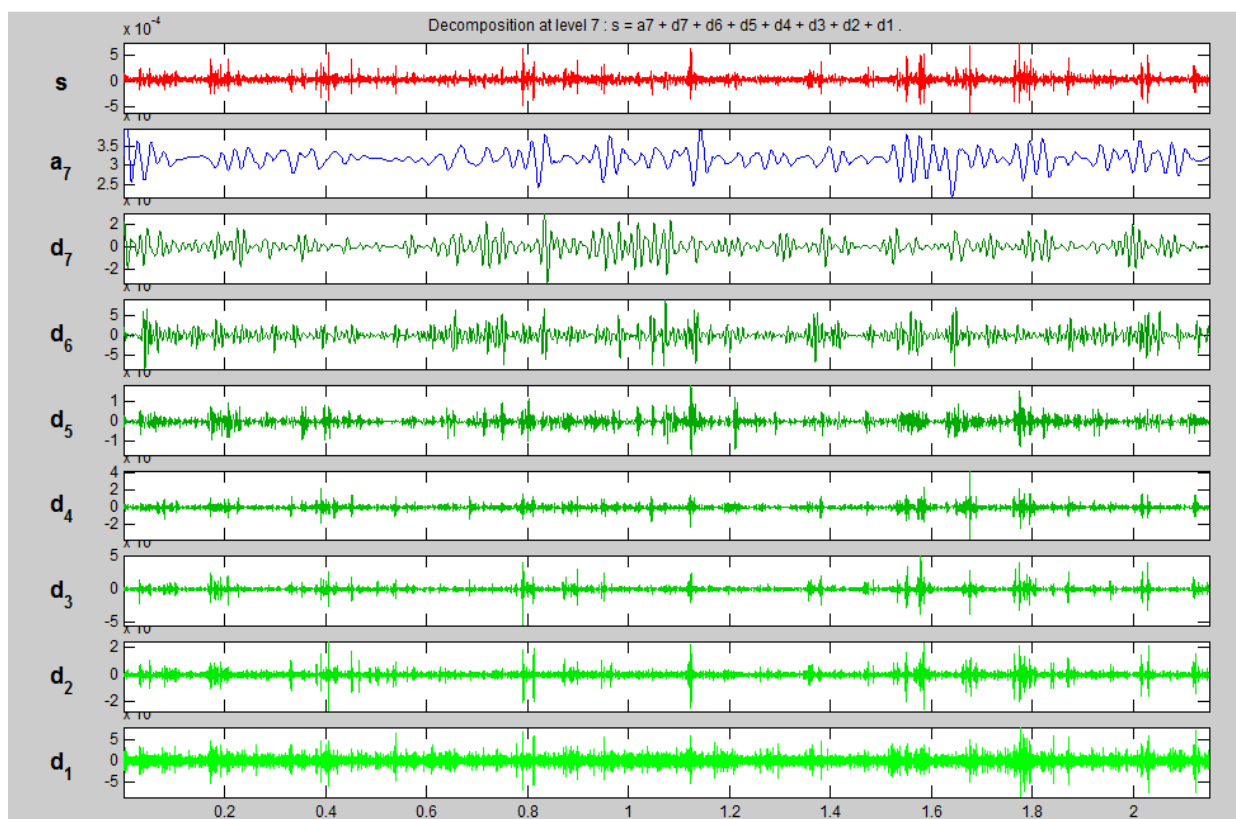The time domain analysis yields such parameters as Root Mean Square (RMS), Mean Rectified Value

Fig. 1: Wavelet decomposition

Table 3: Energy coefficient in wavelet

Category	Ea	Ed_1	Ed_2	Ed_3	Ed_4	Ed_5	Ed_6	Ed_7
15-25	63.6291	3.5056	5.3919	5.6307	6.1774	9.0069	5.2807	1.3777
26-35	6.4307	2.3887	9.9331	29.8197	20.4593	15.4614	12.7748	2.7323
36-45	8.0334	1.1333	11.0138	29.2669	19.5862	14.1161	13.8911	2.9592
46-55	11.3725	4.8867	21.7744	32.6887	14.7060	9.1460	4.0397	1.3861

Table 4: Percentage deviation

Category	Ed_1 (%)	Ed_2 (%)	Ed_3 (%)	Ed_4 (%)	Ed_5 (%)	Ed_6 (%)	Ed_7 (%)
15-25	87.7	80.2	70.1	61.0	69.26	40.2	66.6
26-35	86.1	91.9	96.7	91.2	87.60	76.6	20.0
36-45	72.5	93.8	96.9	91.8	87.90	84.9	6.1
46-55	94.9	98.5	98.5	90.5	84.10	55.7	46.0

(MRV) and frequency domain analysis, the median frequency (Paolo *et al.*, 2001; Reaz *et al.*, 2006). As RMS directly gives number of active motor units and the average firing rate of the active motor units and median frequency gives an index of muscle fatigue, this study compares the contrasting features between diseased with healthy subjects published elsewhere (Vivekanandan *et al.*, 2013b) and the results are shown in Table 1.

After analyzing the data obtained from time domain analysis it is quite evident that the values of RMS and MRV are decreasing from the ideal value. In HD, the bacterial activity fatigues the nerve fibers due to which the firing rate is reduced and so it can be inferred that the RMS and MRV value of such diseased nerve will be drastically reduced. In frequency domain analysis from the power spectrum of the signal, median frequency can be obtained which significantly increases for the HD patient. Median Frequency appears to be an index of muscle fatigue. Upon fatigue, the power spectrum shifts towards the lower side and its median frequency goes up. MRV and RMS values decrease with increase in median frequency with different age groups and corresponding percentage is tabulated in Table 2.

The signal was now subjected to wavelet analysis. Using MATLAB, a code was generated to extract the energy coefficient associated with dB-4 up to the 7 decomposition level as shown in Fig. 1.

Here E_a is the energy of approximated signal. The energy of the wavelets has been tabulated as shown in Table 3. Ed_3 and Ed_4 levels show a drastic increase and similarly Ed_7 value decreased. Hence these particular wavelets can be analyzed for the severity of the disease. The Energy coefficient associated with each wavelet at various decompositions is increased (Dinesh *et al.*, 2003; Saxena *et al.*, 2004). The percentage of deviation from the healthy is analyzed and tabulated (Table 4) (Vivekanandan *et al.*, 2013a, b).

DISCUSSION

This study quantifies myosignal in HD with respect to ulnar nerve and its associated ADM muscle whose results clearly differentiates a healthy from the diseased. This approach can be extended for other HD affected nerves like median nerve in the arm and common peroneal nerve in the leg. The methodology if perfected with a large data base can be used for the early detection of disease before other symptoms set in.

CONCLUSION

Using the features of HD myosignal and qualitative information from the subject this study quantifies and compares the diseased with the healthy by which early diagnosis for HD may be possible with the following conclusions:

- Electrophysiological investigations have an important role in the detection of muscle denervation and neuropathic changes in HD patients. These investigations are safe, rapid and non-invasive.
- EMG has been widely used in the evaluation of HD because it provides for observation of overall muscle response to specific activities, which is often desirable to describe and compare the changes in the pattern of the muscle response.
- The results from the analysis are very clear that the HD affected nerve will always have lower values of RMS and MRV *vis á vis* the healthy.
- The median frequency is always increased and deviates from healthy and can act as a vital parameter in the early diagnosis of leprosy.
- One of the age group in our study (A) consisting of student's shows vast difference with palpable reduction in RMS and MRV. The reason could be improper medication.
- MRV and median frequency can be strong indicators for leprosy diagnosis. Constant monitoring of these parameters can helps study the resolution of the disease under medication.
- Wavelet energy coefficients show distinct difference for HD patients and the percentage variation can be another useful inside information.
- Coefficients evaluated at various levels (e.g., Ed_3, Ed_4 and Ed_7) are functions of nerve energy so the abnormal increase shows the nerve is diseased and can also be an index for diagnosis.

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