EMG Signal Analysis for Identifying Walking Patterns of Normal Healthy Individuals

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Abstract

Surface electromyography is the technique for measuring levels of muscle activity. When a muscle contracts, electrical activity generated as action potentials propagate along the muscle fibers. There are two types of Surface EMG (SEMG)-Static scanning SEMG and Dynamic SEMG. In Dynamic SEMG, electrodes are attached to the skin and muscle activity is measured and graphed as the patient moves through various ranges of motion. The authors in this paper discuss the use of EMG for analyzing different phases of walk by acquiring the surface EMG from Gastrocnemius and Soleus muscles of the leg .with the subjects walking at two self selected pace- fast and slow. These surface EMG signals picked up during the muscle activity are interfaced with a PC system via Biometrics EMG acquisition system. The acquired signals were processed and analyzed using filtering techniques. The results showed a marked variation in the RMS amplitude levels and median frequency of EMG as the subject's walking pace changed.

Keywords *Surface EMG, Gait Analysis, Median Frequency, RMS Amplitude.*

1. Introduction

Human walking is a complex and rhythmic activity. It is well integrated effort of brain, nerves and muscles. It relies on the coordinated action of 28 major muscles to control the jointed trunk and limbs and to generate the forces needed to counter gravity and propel the body forward with minimum energy expenditure [1]. A group of muscles are involved in performing even a single movement like flexion and extension. No two individuals have a similar walking style (gait). There are many reasons-neurological, anatomical and environmental where a human is deviating from his normal gait. In order to assess the exact cause and find a solution to correct an individual's gait, an accurate and quantitative assessment of deviation is required [2]. There are many techniques which have developed over the years. Previous methods were based on observations and prone to errors. Researchers developed contact based method in which sensors like electro-goniometer and accelerometer are attached to individual's limb and their movement is recorded [3]. The limitations of these methods are that the sensor hinders the normal movement and the information available is limited. Later, non-contact or imaging based methods were developed, in which the movements are captured with the help of a camera system [4]. When any of the muscles involved in the gait process do not perform normally, the person's walking pattern may be significantly altered.

Dynamic electromyography (EMG) offers a means of directly tracking muscle activity. The myo-electric signal sufficiently parallels the intensity of muscle action to serve as a useful indicator of its mechanical effect. Amplitude of EMG signals derived during gait may also be interpreted as a measure of relative muscle tension. Data seem to support that the linear envelope of the EMG signal reflects the relative amount of muscle tension. It has been concluded that the relationship is influenced by technique and physiological factors. Delineating the changes in

phasing, duration, or magnitude of muscle action associated with a person's pathological gait pattern, however, is difficult due to the complexity of the EMG record. Its multi-spike, random amplitude quality defies simple interpretation. The timing and intensity of the EMG during a phase or the entire gait cycle informs about neurological control and muscle integration [5]. The difficulties of relating EMG to the corresponding force signals are associated with highly non linear and time-variable relation between these signals, and the difficulty in measuring EMG consistently and repeatedly and in measuring muscle forces in vivo. Magnitude and intensity of the EMG signal is at least qualitatively related to the force produced by a muscle under given condition [6]. It is well accepted in scientific community. The exact EMG- force relationship has been topic of scientific debate. The paper describes the instrumentation, analysis and interpretation of EMG signal for different walking speed of normal healthy individuals. The potential use of this analysis is in controlling the prosthetic device like artificial knee or hand.

2. Method and Materials

The experiments were conducted using Biometrics EMG acquisition system. The EMG preamplifier fitted electrodes were fixed to the Gastrocnemius and Soleus muscles of both the legs of the subject using medical grade both sided tapes. The electrodes were placed at the motor points of the selected muscles on both the legs of the subject as seen in Figure.1. To prevent the electrodes from being displaced from their fixed locations during the course of the experiment tapes were used. The ground strap of the EMG setup was worn on the left leg. The leads of all the four pre amplifiers were fed to the DataLINK base-unit DLK900 of the EMG acquisition system which acted as an interface to the PC.

The subject was instructed to walk a few rounds before actual data acquisition to get familiar walking with the setup intact. Three sets of data were acquired, with the subject walking at self selected speed for fast and slow walking. The collected data was stored and analyzed offline using Biometrics Management Software. The instrumentation set up for the experiment is as in the schematic shown in Figure 2.

Figure 1: Subject wearing electrodes at muscle locations- Gastrocnemius and Soleus muscles.
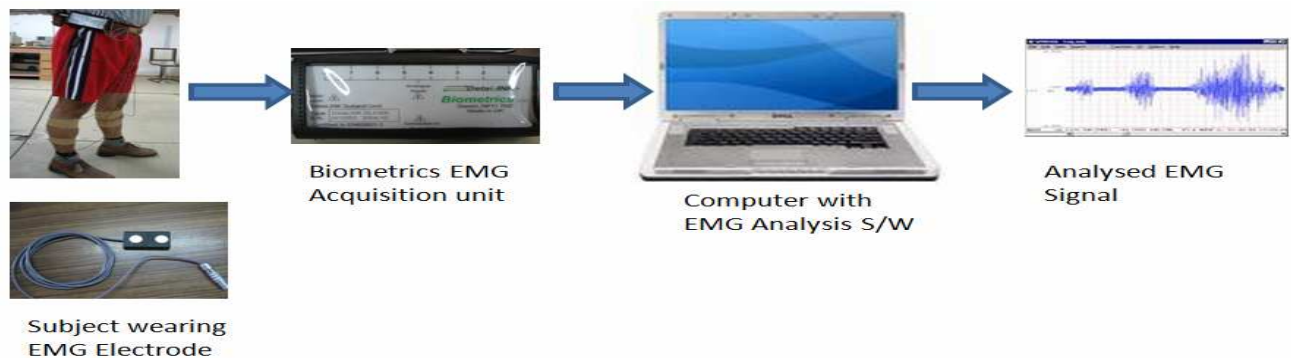

Figure 2: Instrumentation Scheme

3. Software Analysis

For analyzing the data using Biometrics Management software we chose two major parameters; amplitude and frequency. All the three sets of data were analyzed using RMS filters and median frequency filters. The initial and terminating portions of the signals were ignored for analysis to avoid any noise creeping in. For amplitude analysis we used an RMS filter with filter constant of 100 ms. For frequency analysis Median frequency filter with filter constant of 64 Hz was used. The mean values of all the three walking trials were identified and averaged to get a mean for fast and slow walks both for amplitude and frequency.

4. Results and Discussions

The acquired EMG signals are as shown in Figure 3(a & b). The pre amplified EMG signals for the right and left Gastrocnemius leg muscles are as shown in the top and bottom graphs of Figure 3(a) respectively. The pre amplified EMG signals for the right and left Soleus leg muscles are as shown in the top and bottom graphs of Figure 3 (b) respectively. Similarly Figure 4(a) show the RMS filtered EMG signals from Gastrocnemius for both limbs, Figure 4(b) shows the RMS filtered EMG signals from Soleus for both limbs, Figure 5(a) shows the Median Frequency filtered EMG signals from Gastrocnemius for left and right limb and Figure 5(b) shows the Median Frequency filtered EMG signals from Soleus for both limbs.
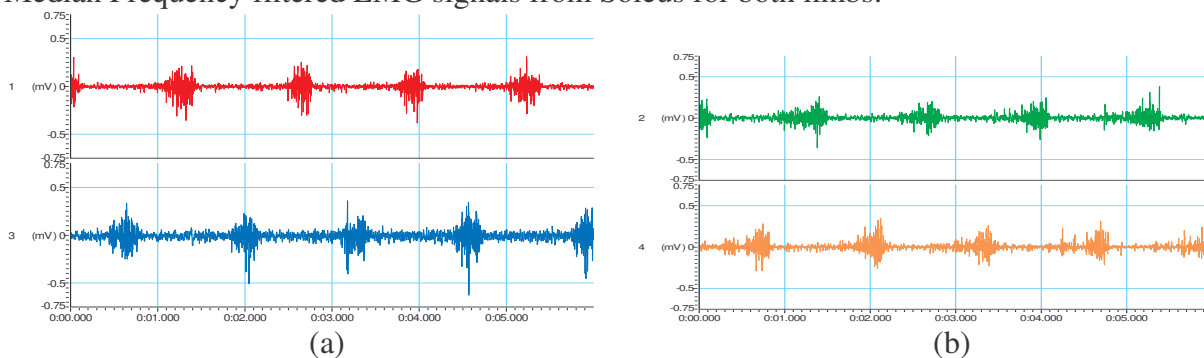

(a) (b)

Figure 3(a) Acquired EMG signals from Gastrocnemius for left and right limb. (b) Acquired EMG signals from Soleus for left and right limb.
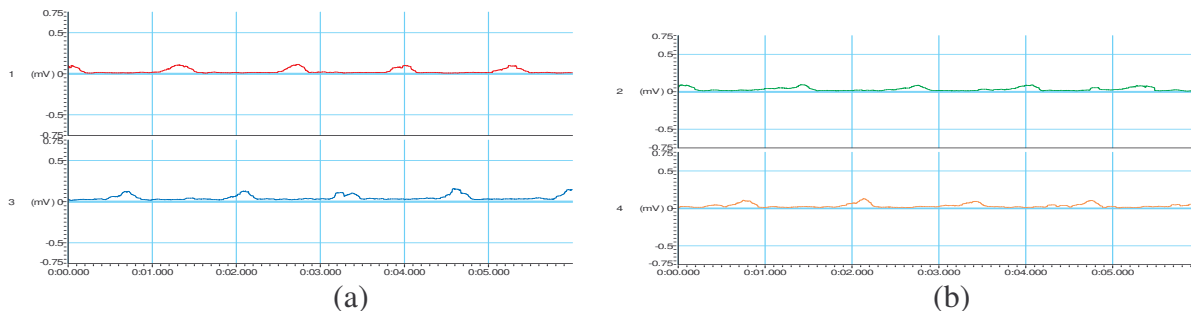

(a) (b)

Figure 4(a) RMS Filtered EMG signals from Gastrocnemius for left and right limb. (b) RMS filtered EMG signals from Soleus for left and right limb.

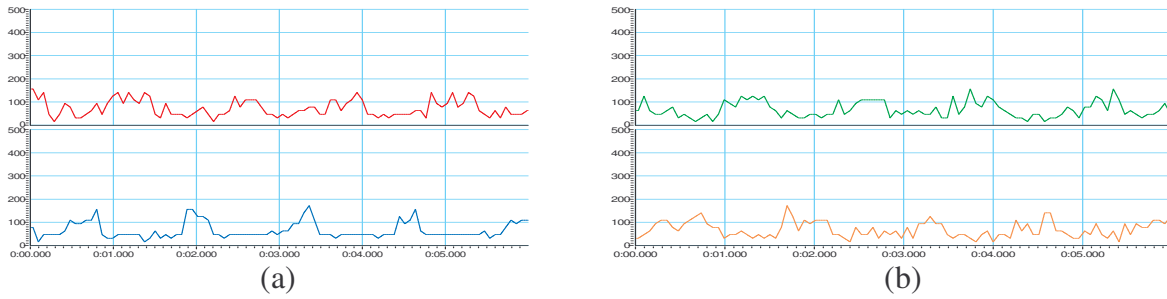(a)   (b)

Figure 5(a) Median Frequency filtered EMG signals from Gastrocnemius for left and right limb. (b) Median Frequency filtered EMG signals from Soleus for left and right limb.

The SEMG data for the RMS values of amplitude is analyzed and tabulated in Table.1 and that for median frequency is tabulated in Table 2. The trace titles GRL and GLL refer to the signal obtained from Gastrocnemius Right Leg and Gastrocnemius Left Leg respectively. Similarly trace titles SRL and SLL refer to the signal obtained from Soleus Right Leg and Soleus Left Leg respectively.

Channel	Trace Title	Fast Walk in (mV)	Slow Walk in(mV)
1	GRL	.04473	.0367
2	SRL	.05550	.0385
3	GLL	.06650	.0502
4	SLL	.05820	.0404

Table 1: Mean amplitude of EMG signal averaged over three trials for fast and slow walks

It can be observed from the table the RMS value of the signal amplitude tends to increase from slow to fast walk for both muscles of both the limbs this can be attributed to the increase in motor activity with increase in speed of movement. Another notable observation is the variation in amplitude of the signal for the same muscle of both limbs for fast and slow walks is similar.

Channel	Trace Title	Fast Walk in (Hz)	Slow Walk in(Hz)
1	GRL	69.00	84.77
2	SRL	72.45	73.60
3	GLL	63.45	66.01
4	SLL	65.20	69.60

Table 2 Median Frequency averaged over three trials for fast and slow walks

The median frequency component follows a pattern where the frequency decreases with increase in walk speed. Also variation in median frequency of the signal for the same muscle of both limbs for fast and slow walks is similar.

5. Conclusions

The paper describes the EMG pattern variations of Gastrocnemius and Soleus muscles with the help of surface EMG. The EMG is classified on the basis of RMS amplitude values and

frequency analysis. It can be concluded that the variation in amplitude and median frequency of EMG signal can be used to identify the speed of walk of a normal human. There is need to identify the normal ranges of EMG variations of local population. This would help in order to develop EMG based controls.

Acknowledgment

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