EMG Signal Analysis for Different Sitting Postures with and without Backrest

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***Abstract*— The purpose of this study was to examine the stress analysis during flexion and erection movement of human back during occupation at different positions with and without backrest using surface Electromyography (sEMG) signal. This tool is a non-invasive technique that allows the evaluation of muscle activity. Human's back is most sensitive part of human body and postures of human body have a significant role to analyze pain especially in the low back region. In this approach surface electrodes are used to record surface electromyography (sEMG) signals of lower back, in the limited forward and backward movement from vertical position, placed at different positions of vertebrae of the lumber region to have a prediction on the stress level of muscles involved in the movement. Preliminary Investigation on three subjects of age groups below 40 years and above 40 years was carried out for three different sitting postures to analyze the differences in EMG signals using Analysis of variance (ANOVA). After Preliminary investigation on three subjects, the experiment was extended to three more subjects in three different sitting postures with and without backrest. ANOVA test has clearly indicated that there exists a statistically significant difference amongst the mean values of EMG signals for different sitting postures and in further investigation, it was found the mean EMG is significantly different with and without backrest also.**

Keywords*— Force, low back pain, position of lower back, sEMG

I. INTRODUCTION

The spine is a complicated structure providing support to the body [12]. One important mechanical function of the lumbar spine is to support the upper body by transmitting compressive and shearing forces to the lower body during the performance of everyday activities [4]. In recent times, low back pain is a common problem in all working professionals. In spite of growing knowledge pertaining to spinal diseases and momentous developments in modern medicine, chronic low back pain (LBP) remains one of the most severe public health problems in all countries including India. Low back pain is the leading musculoskeletal disorder in terms of cost and work-absenteeism [1]. The effectiveness of different kinds of treatments has been studied in the literature, but a definite consensus has yet to be established [13]. LBP causes a socio-economic impact promoting many days lost in work [14]. Several studies suggest that instability can cause damages and lumbar dysfunctions and increase the risk of an initial episode and subsequent recurrence of LBP [3, 5]. Severe back pain most often arises from intervertebral discs, apophyseal joints and sacroiliac joints, and physical disruption of these structures is strongly but variably linked to pain [7]. More of the people with persistent back pain who report limitations in functioning have used health care services compared with others in the sample who also reported functional limitations, presumably resulting from health conditions other than back pain [11].Therefore, many authors have recommended inclusion in rehabilitation programs of exercises specifically designed to improve active stability of the spine [8,10].

The main motivation of this paper is to study the effect of sitting postures at different angles, which is primarily the main cause of occupational pain. Another purpose of the paper is to investigate the stress level of the muscles involved in these postures using Electromyographic (EMG) signals. The present study involves study of effect of different sitting postures with and without back rest. Extensive researches were made to understand the surface EMG techniques and its application to the analysis of low back muscles for classifying healthy subjects and Low back pain (LBP) patients [14]. EMG signal provides the information regarding the muscle activity and is used for investigation of lumbar spine [15]. This work is to further the work already carried out on EMG based investigations.

II. EXPERIMENTAL SETUP

To improve understanding of the dynamic characteristics of the human lumbar spine, experimental method is required [6]. For this work, MP100 of Biopac System Incorporation has been used for recording EMG signals. MP100 is a complete and expandable data acquisition system that functions like an onscreen chart recorder, oscilloscope and X/Y plotter, which allows recording, viewing, saving and printing data [16].

A. Data Acquisition Settings

The data acquisition involves the recording of Electromyographic (EMG) activity [2]. Muscle activities from the lower back were recorded from the disposable surface electrodes (EL-503) connected to the MP100 Biopac Systems Inc. Another important part in data acquisition is the amplification and signal conditioning, which includes artifact

elimination of the signals. Since the SEMG signals are relatively small, their measurement is susceptible to the movement of cable that carries signals from the body to the measuring instrument. To eliminate these artifacts, the Electromyogram amplifier module (EMG 100C) high gain, differential input, biopotential amplifier has been used to acquire the EMG with 10-500 Hz bandwidth and gain setting of 2000. The sampling rate was selected to be 1000 Hz so that none of the useful information was lost during data acquisition. The placement procedure of electrodes will be explained in the next subsection.

B. Placement of electrodes and duration of recording

The surface electrodes were placed with a careful observation of anatomical studies of the muscles concerned with the lower back. EMG data was taken by using two channels of the equipment. The skin preparation was duly done prior to the placement of electrodes. The two active disposable Ag/AgCl surface electrodes were used for each channel in differential configuration at one and half centimeter distance from each other. The third surface electrode was placed as the reference electrode on the unconcerned muscle.

Surface electrodes were placed at the skin surface of Erector Spinae at right side and were assigned as Channel1 for L_1 and L_3 and Channel2 for L_3 and L_5. The placement of channel 1 was to the right side of lumbar vertebrae, L_1 and L_3 on right erector spine muscle second channel was placed on L_3 and L_5. Recordings for a subject were taken for each position for a window of 60 seconds with and without back rest.

III. SUBJECTS AND SUBJECTS POSTURES

For purpose of the experimental analysis, two stage experiments have been conducted:

1. Preliminary Investigation: Three subjects of age groups below 40 years and above 40 years were considered for three different sitting postures to analyze the differences in EMG signals for a window of 10 sec each.
2. After Preliminary investigation on three subjects, the experiment was extended to seating with and without backrest. Same subjects (male and female) participated in the experiment with their written consent. The required essential training for the desired positions of the back was imparted to each subject individually. Back positions were separated by 15 degrees. The three positions of back for which the data was acquired are selected as 75^0, 90^0 and 105^0 from horizontal plane.

IV. FEATURE EXTRACTION

Generally, most of signals in practice are time-domain signals in their raw format. In other words, one obtains a time-amplitude representation of the signal. The main purpose of the feature extraction is to emphasize the important information in the measured signal. After the successful processing of the sEMG signal, it was required to extract the features of different positions of back. One may easily evaluate the features in time domain because time domain does not need a transformation. Mean, variance and root mean square time domain features were extracted from acquired EMG signals and has been used for analysis purpose.

V. RESULTS

For Preliminary investigation, one way Analysis of Variance (ANOVA), a statistical method was used to test the differences between the mean values of EMG signals of three different sitting postures without back rest. The Preliminary test was conducted on three subjects and absolute mean values of EMG signals for a window of 10 sec each is given in Table-1.

Null Hypotheses: means of all the EMG signals at different angles of sitting posture are equal.

Alternative Hypotheses: means of all the EMG signals at different angles of sitting posture are not equal.

Results of ANOVA test for three subjects are presented in Table-2.

It is clear from the ANOVA method that the p values are considerably lower than 0.05. So the null Hypotheses is rejected and alternate Hypotheses is accepted. It is concluded that the EMG activity is significantly (statistically) different at different angles of sitting postures.

After the preliminary investigation, the experiment was extended to sitting with backrest and without backrest with three different sitting postures. Two channels for two different locations (L_1 -L_3 & L_3-L_5) were utilized for each recording. In this analysis, a window of 60 seconds for gross activity and a window of 10 seconds for short duration study have been used for the feature extraction. Table 3 shows the absolute mean values at three different positions for 10 seconds window for three subjects sitting (without rest) ideally with hands down.

For further understanding the behaviour of EMG signals for without and with back rest, the ANOVA test was again applied if there exists a statistically significant difference between absolute mean EMG activity of same position with backrest and without back rest. The Table 4 shows the results of ANOVA test applied on EMG recordings of subject1. Result clearly indicate p values as .012, which is much lower than .05 and it can be concluded that there exists a statistical difference in the mean value of EMG for same sitting posture with and without backrest. It can be observed from the table3 that the EMG activity is significantly low in with backrest recordings.

Further the absolute mean EMG activity is also calculated in Table 5 for gross window of 60 sec. Bar graph in Figure 1, Figure 2 and Figure 3 have been plotted to show the gross EMG activity for 60 sec window for three subjects for three different sitting postures with and without backrest.

It is evident from above bar graphs that gross EMG activity is significantly low in sitting postures with backrest almost in all the cases. However, the difference is not constant all along the recordings.

VI. DISCUSSION

The positions of back were investigated by the EMG signals. There is difference in absolute mean values of EMG signal for different sitting posture. Further, ANOVA test has clearly indicated that there exists a statistically significant difference amongst the absolute mean values for EMG signals for different sitting postures, which shows the possibility of investigating the good posture of back using EMG signals. Further ANOVA test has also confirmed the statistically

significant difference in the values of EMG in sitting with and without backrest. The window selected for the analysis helps us to analyze the changes in EMG signals with time, so it is always better to select a proper window before extracting the features. It has been also observed that the difference between the EMG activity for with and without rest is not consistence all along. This may be due to recording is required to be made at different point of time. Further this difference is not same for angles of sitting. This difference is required to be investigated further with larger number of subjects.

It is clear from this study that the backrest support reduces the EMG activity and it can be concluded that accordingly muscles are under lower stress level while sitting with backrest. So it can be recommended that while sitting on seat with backrest it is desirable that backrest be utilized for giving a comfort to back and this may result in reduced danger for back pain in professions requiring long duration of seating.

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