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A Study on Stress Analysis of Lower Back By Means Of Electromyography Signal

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Abstract - The motive of this study used to be to study the force/EMG relationship during flexion and erection motion of human returned for the duration of occupation at special positions the use of floor Electromyography (sEMG) signal. This tool is a non-invasive method that allows the assessment of muscle activity. Human's again is most sensitive part of human physique and postures of human body have a full-size role to analyze pain, specially in the low returned region. In this strategy floor electrodes are used to document surface electromyography (sEMG) indicators of decrease back, in the constrained forward and backward movement from a vertical position, placed at specific positions of vertebrae of the lumber region to have a prediction on the stress stage of muscle tissues involved in the movement. Preliminary Investigation on three topics of age businesses below forty years and above 40 years used to be carried out for three special sitting postures to analyze the differences in EMG signals using Analysis of variance (ANOVA). After Preliminary investigation on three subjects, the experiment used to be prolonged to nine subjects in six unique sitting postures. ANOVA test has genuinely indicated that there exists a statistically sizable difference amongst the mean values of EMG signals for one-of-a-kind sitting postures and in in addition investigation, the minimum stress degree is found in the attitude vary from 90°-120°. According to the minimal stress degree between the perspective vary 90°-120°, the seat may additionally be designed such as returned rest flexibility in the attitude range of 90°-120°.

Keywords: Position of decrease back, sEMG, Force, Low back pain.

Introduction

The backbone is a complex shape supplying assist to the physique [1]. One essential mechanical feature of the lumbar backbone is to assist the higher body by way of transmitting compressive and shearing forces to the decrease body in the course of the overall performance of daily activities [2]. In current times, low back ache is a frequent problem in all working professionals. In spite of developing information pertaining to spinal illnesses and momentous trends in contemporary medicine, continual Low Back Pain (LBP) remains one of the most extreme public fitness problems in all nations such as India. Low lower back pain is the leading musculoskeletal disease in phrases of value and workabsenteeism [3]. The effectiveness of exceptional sorts of treatments has been studied in the literature, however a exact consensus has but to be hooked up [4]. LBP causes a socioeconomic affect promotion many days lost in work [5]. Several studies suggest that instability can cause damages and lumbar dysfunctions and extend the threat of an preliminary episode and subsequent recurrence of LBP [6,7]. Severe lower back ache most often arises from intervertebral discs, apophyseal joints and sacroiliac joints, and bodily disruption of these buildings is strongly however variably linked to pain [8]. More of the humans with chronic back pain who report boundaries in functioning have used health care offerings compared with others in the pattern who also reported useful limitations, presumably ensuing from fitness conditions other than back pain [9]. Therefore, many authors have advocated inclusion in rehabilitation programs of exercises specially designed to improve active balance of the backbone [10,11]. The important motivation of this paper is to study the effect of sitting postures at unique angles, which is notably the primary purpose of occupational pain. Another reason of the paper is to inspect the stress stage of the muscle tissues involved in these postures using Electromyographic (EMG) signals. Muscle pastime is immediately reflected by EMG signals. Low muscle activity suggests less electricity is required to preserve the posture. So such a study will be useful ergonomic intervention to suggest a ideal sitting angle. The applicable posture is associated with elastic equilibrium, in which the least elastic stress and lowest joint load are produced [12], which is reflected by way of the low tiers of muscle activity. The desirable posture suggest the much less electricity required to maintain the posture and ultimately may additionally end result in heading off occupational health hazard main to decrease back pain. The learn about embodies the experimental investigation of the physical coaching and data acquisition of the decrease lower back positions. The elements of records pre-processing stage, which is an essential phase to analyze the sign for characteristic extraction, are additionally incorporated. Surface electromyography (sEMG) signals are the most frequent shape of non-invasive-measurement of muscle activities [13] and are widely widely wide-spread and used for investigation of muscle stress. Extensive researches have been made to understand the surface EMG techniques and its software to the analysis of low back muscle groups for classifying healthy subjects and Low Back Pain (LBP) sufferers [5].

Material and Methods

Experimental setup

To enhance perception of the dynamic characteristics of the human lumbar spine, the experimental method is required [14]. For this work, MP100 of Biopac System Incorporation has been used for recording EMG signals. MP100 is a entire and expandable statistics acquisition machine that functions like an onscreen chart recorder, oscilloscope and X/Y plotter, which allows recording, viewing, saving and printing data [15]. Data acquisition settings: Muscle things to do from the decrease again have been recorded from the disposable floor electrodes (EL-503) linked to the MP100 Biopac Systems Inc. The data acquisition includes the recording of Electromyographic (EMG) undertaking [16].

Another important phase in records acquisition is the amplification and sign conditioning, which includes artifact removal of the signals. Since the SEMG alerts are enormously small, their size is inclined to the motion of cable that incorporates indicators from the physique to the measuring instrument. To take away these artifacts, the Electromyogram amplifier module (EMG 100C) excessive gain, differential input, biopotential amplifier has been used to acquire the EMG with 10-500 Hz bandwidth and acquire setting of 2000. The sampling fee used to be selected to be a thousand Hz so that none of the useful statistics was lost at some point of facts acquisition. The placement procedure of electrodes will be defined in the subsequent subsection.

Table 1. Feature values of EMG signals for three different angles for preliminary investigation.

Angle of Back	Subject 1		Subject 2		Subject 3	
	Average Value	Standard Deviation	Average Value	Standard Deviation	Average Value	Standard Deviation
75°	0.718743	0.563316015	0.447931	0.12138183	1.643806	0.9744
	0.703388	0.515772916	0.417474	0.12323651	1.708665	0.9951
	0.405779	0.281859859	0.310476	0.12518218	1.756806	1.0428
	0.479794	0.402271978	0.200008	0.12300078	1.777084	1.0467
	1.485074	1.333926257	0.264942	0.12272625	1.775545	1.0515
	0.447859	0.410923564	0.433159	0.12320205	1.816283	1.0762
90°	0.213493	0.155064423	0.391967	0.266012138	0.792189	0.4618
	0.212597	0.153007881	0.327655	0.225684525	0.845401	0.4866
	0.306643	0.397730595	0.375299	0.247464197	0.867605	0.4961
	0.428785	0.286482375	0.246629	0.158845505	0.825746	0.4885
	0.471512	0.310411638	0.333409	0.25919276	0.900564	0.5242
	0.508391	0.35971465	0.521975	0.337426988	0.906899	0.5251
105°	0.306535	0.148747823	0.494207	0.11921041	0.977155	0.5742
	0.243737	0.124624189	0.499736	0.11901171	0.985729	0.5729
	0.210168	0.113682065	0.512191	0.11969711	0.946091	0.5468
	0.177581	0.103052894	0.513105	0.12025388	0.894297	0.5216
	0.154409	0.095064539	0.509925	0.12078698	0.8356	0.4851
	0.142599	0.089057657	0.511921	0.12092837	0.841688	0.4842

Placement of electrodes and period of recording: The surface electrodes have been placed with a cautious remark of anatomical research of the muscle mass concerned with the lower back. EMG data was taken via using two channels of the equipment. The skin education was duly performed prior to the placement of electrodes. The two lively disposable Ag/AgCl floor electrodes have been used for every channel in differential configuration at one and 1/2 centimeter distance from each other. The 1/3 surface electrode was once positioned as the reference electrode on the unconcerned muscle. Surface electrodes had been positioned at the skin floor of Erector Spinae at right facet and had been assigned as Channel 1 for L1 and L3 and Channel 2 for L3 and L5. The placement of channel 1 used to be to the proper aspect of lumbar vertebrae, L1 and L3 on proper erector spine muscle second channel used to be placed on L3 and L5. All recordings for a challenge have been taken for each role for a window of 10 sec without again rest.

Subjects and subjects' postures

For purpose of the experimental analysis, two stage experiments have been conducted: Preliminary investigation: Three subjects of age agencies below forty years and above 40 years had been viewed for three distinctive sitting postures to analyze the variations in EMG alerts for a window of 10 sec each.

Table 2. ANOVA test summary for three subjects for three different sitting postures.

ANOVA: Single Factor						
Subject 3						
SUMMARY						
Groups	Count	Sum	Average	Variance		
75°	6	5.138406	0.856401	0.001962		
90°	6	10.47819	1.746365	0.003746		
105°	6	5.480562	0.913427	0.004385		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	2.978146	2	1.489073	442.5829	4.61E-14	3.68232
Within Groups	0.050468	15	0.003365			
Total	3.028614	17				

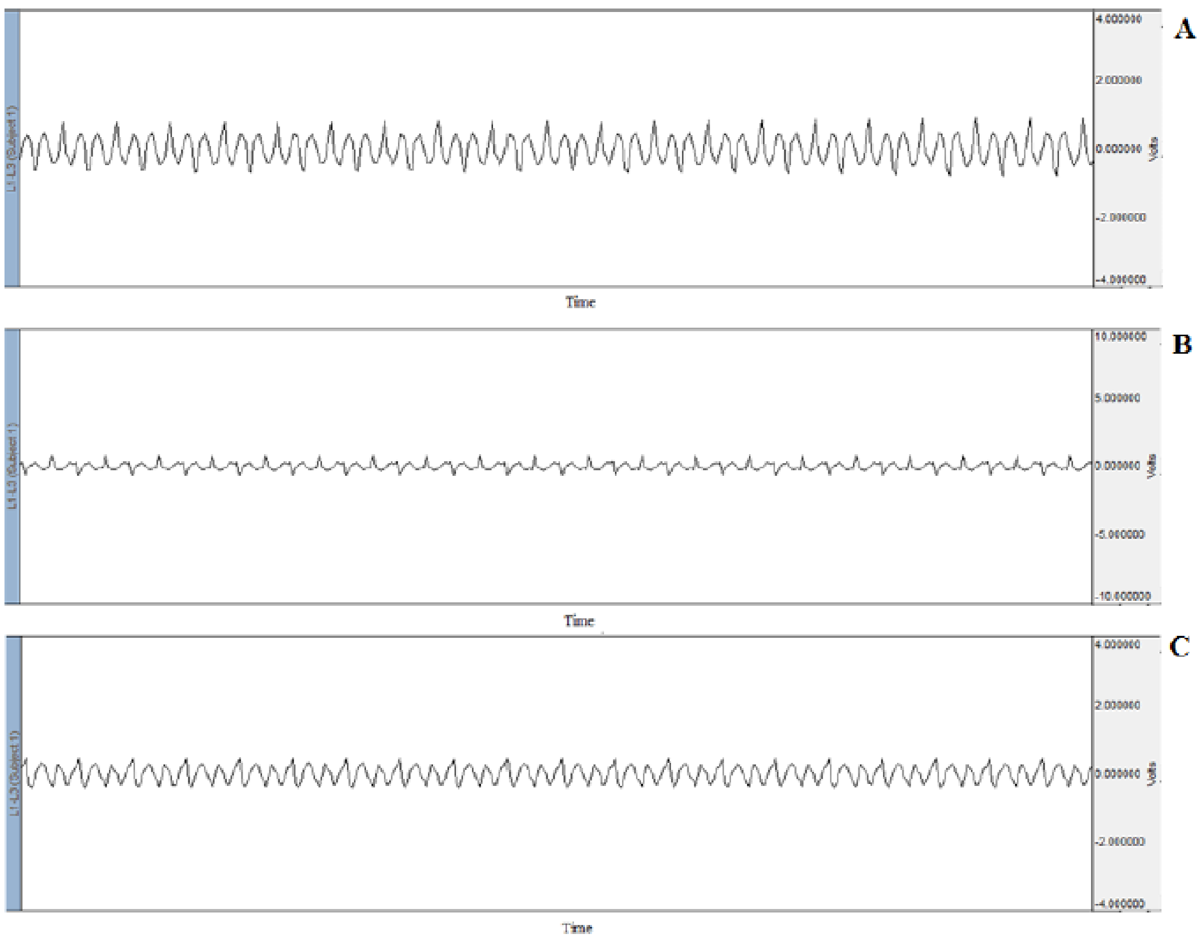


Fig. 1. sEMG signals of Subject 1 at different sitting postures at (a) 75 (b) 90 (c) 105

After Preliminary investigation on three subjects, the test was extended to 09 subjects in six extraordinary sitting postures barring backrest. Healthy subjects (male and female) aged 20-30 years were chosen and they have participated in the test with their written consent.

Table 3 Angle for minimum gross stress level of EMG.

Subject	L_1-L_3 location	L_3-L_5 location
Subject 1	105°	90°
Subject 2	90°	90°
Subject 3	90°	90°
Subject 4	90°	90°
Subject 5	90°	120°
Subject 6	90°	120°
Subject 7	120°	90°
Subject 8	105°	105°
Subject 9	105°	90°
Total	90°-11 times (61.1%)	
	105°-4 times (22.2%)	
	120°-3 times (16.6%)	

The required indispensable education for the desired positions of the returned was once imparted to every problem individually. Back positions were separated by using 15 degrees. The six positions of the back for which the statistics used to be acquired are selected at 45°, 60°, 75°, 90°, 105° and 120° from the horizontal plane.

Feature extraction

Generally, most of the indicators in practice are time-domain alerts in their raw format. In other words, one obtains a time-amplitude representation of the signal. The important purpose of the characteristic extraction is to emphasize the important information in the measured signal. After the profitable processing of the sEMG signal, it used to be required to extract the facets of special positions of the back. One may additionally without problems consider the elements in the time domain because the time area does not need a transformation. Absolute imply and variance time area aspects had been extracted from received EMG alerts and have been used for analysis purpose.

Results

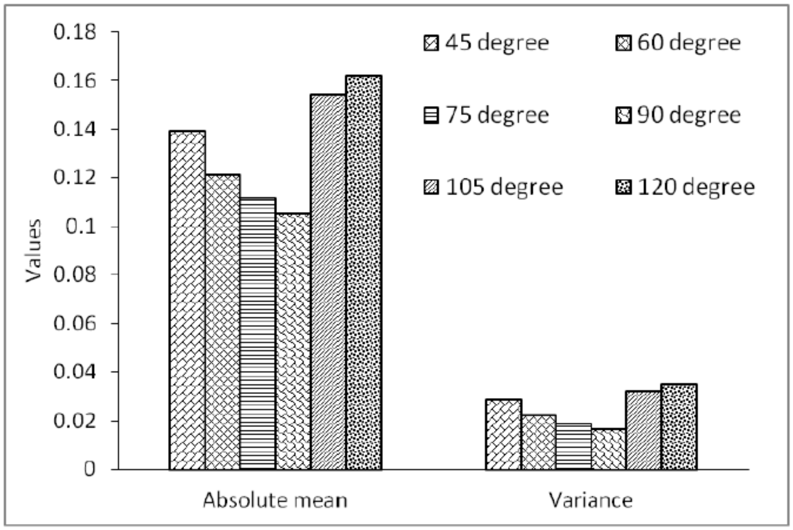
For Preliminary investigation, one-way Analysis of Variance (ANOVA), a statistical approach used to be used to check the variations between the suggest values of EMG signals of three distinct sitting postures. The Preliminary take a look at was once conducted on three subjects and absolute imply values of muscle recreation (EMG) for a window of 10 sec every have been recorded and introduced in Table 1. Null hypotheses: capability of all the EMG alerts at distinct angles of sitting posture are equal. Alternative hypotheses: capacity of all the EMG signals at different angles of sitting posture are not equal. Results of the ANOVA test for one situation is in Table 2. P-value of ANOVA take a look at for different two was once observed 0.009447 0.005992 respectively.

Table 4. Minimum stress level of EMG signal at different angles (2 sec window).

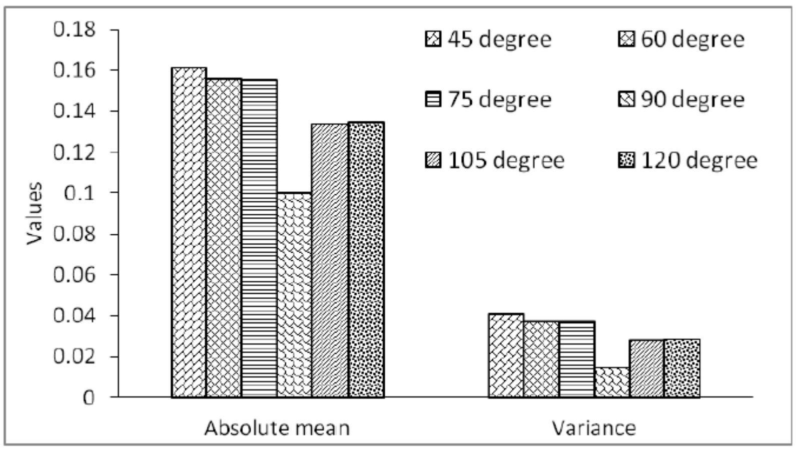
Subject	L_1-L_3 location						L_3-L_5 location					
	45°	60°	75°	90°	105°	120°	45°	60°	75°	90°	105°	120°
1	0	0	0	0	5	0	0	0	0	5	0	0
2	0	0	0	5	0	0	0	0	0	5	0	0
3	0	0	0	5	0	0	0	0	0	5	0	0
4	0	0	0	2	3	0	0	0	0	2	0	3
5	0	0	0	5	0	0	0	0	0	0	0	5
6	0	0	0	5	0	0	0	0	0	0	0	5
7	0	0	0	0	0	5	0	0	0	5	0	0
8	0	0	0	1	4	0	0	0	0	0	5	0
9	0	0	0	0	5	0	4	0	0	1	0	0
Total	0	0	0	23	17	5	4	0	0	23	5	13
% of occurrence of min. stress	0	0	0	51	38	11	9	0	0	51	11	29

It is clear from the ANOVA method that the p values are considerably lower than 0.05. So the Null Hypothesis is rejected and alternate Hypothesis is accepted. It is concluded that the EMG activity is significantly (statistically) different at different angles of sitting posture (Figure 1). Each EMG value represents muscle activity during different sitting with trunk inclinations in flexion and extension positions from the sagittal plane [17]. After the preliminary investigation, the experiment was extended to nine subjects with six different sitting postures without backrest. Two channels for two different locations (L1- L3 & L3-L5) were utilized for each recording. In this analysis, a window of 10 sec. for gross activity and a window of 2 sec. for short duration study have been used for the feature extraction. Figure 2 shows the feature values at six different positions for a 10-sec window for three subjects sitting (without backrest) ideally with hands down. It clearly indicates that the EMG output varies for different angle positions of the back and comes out to be minimum at 90° in most of the cases.

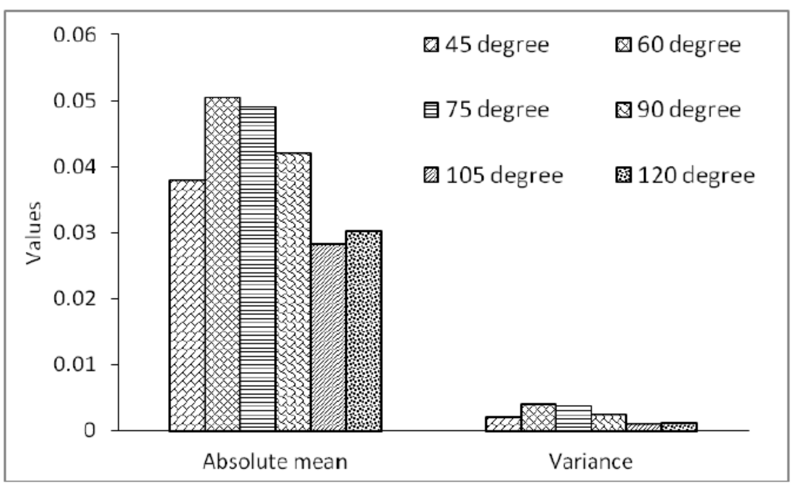
For further understanding, the behavior of back signals the Table 3 shows the angle for minimum gross stress level of EMG for lower back for the considered nine subjects. It is evident from Table 3, the minimum stress level is found maximum times at an angle of 90° i.e. 61%. In rest of the cases, the minimum stress level is found at an angle of 105° and 120°. Further analysis EMG is analyzed in a smaller window of 2 second each i.e. each 10 sec. the recording is divided into 5 parts of 2 sec. each. Table 4 presents the angle of minimum stress level for each 2-second window. It is evident from Table 4, the minimum stress level is found maximum times at an angle of 90° i.e. 51% for L1-L3 and L3-L5. Next minimum stress level was found at 105° i.e. 38% for L1-L3 and 11% for L3-L5. Few cases of minimum stress level were found at 120° i.e. 11% and 29% for L1-L3 and L3-L5 respectively. In rest of the cases (9%) the minimum stress level is found at an angle 450 for L3-L5 position.



(a) Feature values of Subject 1 at L1-L3 position



(b) Feature values of Subject 4 at L1-L3 position



(c) Feature values of Subject 9 at L1-L3 position

Figure 2. Feature values of subjects.

Discussion

SEMG has been used in numerous settings to measure the voltage output of relative muscle recruitment, in ergonomic analyses when evaluating musculoskeletal stress in a specific muscle(s) associated with postures and to evaluate the efficacy of ergonomic interventions [18,19]. The study utilizes the common amplitude measurement from the sEMG to grant quantitative remark of recruitment intensity for precise muscle businesses affected via a task. The analysis used average amplitude at once instead than the often-used percent of most voluntary contraction due to the fact some topics had active accidents and were unable to acquire a dependable most reading [20].

Mastalerz and Palczewska observed the statistical influence of the trunk inclination on erector spinae, gastrocnemius lat. and tibialis anterior (p<0.05) [17]. Similarly, in our preliminary investigation, it has been concluded that the EMG endeavor is substantially (statistically) unique at unique angles of sitting posture. A study on the impact of postural angle on returned muscle pastime by using Kamil and Md Dawal [12] concluded that neutral top trunk posture, in which the attitude deviates between 0° and -5°, minimizes CES and longissimus muscle activation. This posture approves the challenge to maximize balance and optimize the proportions of their body mass and framework based on their bodily barriers whilst performing laptop tasks. Low muscle undertaking shows less energy is required to keep this posture due to the fact the muscle groups are at their perfect size in a neutral position. The impartial posture is related with elastic equilibrium, in which the least elastic stress and lowest joint load are produced [19], which is mirrored with the aid of the low ranges of muscle activity. The neutral top trunk role can be regarded the perfect posture due to the fact it encourages proper alignment of the body's segments such that the least amount of power is required to maintain the favored function [12]. In our study occurrence of minimum stress is at an angle 900 for 61% of the readings taken (gross EMG) from nine subjects and is apparent that minimal stress level is by and large determined in the angle 900 which is equivalent to the neutral position.

Conclusion

The positions of lower back have been investigated via the EMG signals. There is distinction in feature values of EMG signal for distinct sitting posture. Further, ANOVA take a look at has clearly indicated that there exists a statistically enormous difference amongst the suggest values for EMG indicators for extraordinary sitting postures, which shows the opportunity of investigating the top posture of again the usage of EMG signals. The window chosen for the evaluation helps us to analyze the modifications in EMG indicators with time, so it is always better to pick out a perfect window before extracting the features. It is also clear from Table three and Table four that incidence of minimum stress is at an perspective 900 for 61% of the readings taken (gross EMG) from 9 topics and is obvious that minimal stress stage is located in the angle vary from 90°-120°. This reality was once also tested when shorter length window (2 sec) of EMG was once taken for analysis. So the comfort sitting posture retaining minimal stress of every person can also range between the angles range of 900-1200 from the horizontal plane.

Accordingly, the seat graph might also consist of again rest flexibility in the angles vary of 90°-120°.

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