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IMPACT OF AGE ON POTENTIAL CTS SYMPTOMS AMONGST SHOCKER MANUFACTURING ASSEMBLY LINE WORKERS

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Abstract

In this communication an attempt has been made to examine the impact of age on potential Carpal Tunnel Syndrome (CTS) symptoms amongst shocker manufacturing assembly line workers in actual industrial environment through questionnaire and physical tests. Chi-square test and Surface electromyography (sEMG) signal values have been used for statistical data analysis. The chi-square test result reveals that probability of having CTS symptoms is more amongst workers beyond 35 years of age. Data indicates that 61.76% workers beyond 35 years of age whereas 25% of the workers having age less than 35 years of age are CTS symptoms sufferers. The sEMG signal analysis result reveals that the lesser muscle activity values (EMG-RMS values) indicate the contribution of CTS symptom in shocker assembly line workers.

***Keywords**:* Carpal tunnel syndrome, age, surface electromyography, abductor pollicis brevis, assembly line.

1. Introduction

Carpal Tunnel Syndrome (CTS), a type of Repetitive Strain Injury (RSI) is the most commonly work related musculoskeletal disorder (WMSD) that can lead to temporary as well as permanent disabilities. WMSD is a common problem of medical health in working population. WMSDs can cause pain or numbness, lost work time, and an increase in worker's compensation costs. Examples of WMSDs include back strain, shoulder tendonitis, and CTS (Patry *et al.*, 1998, Fagarasanu & Kumar, 2003). CTS is brought on by over-worked, over-strained muscles of arms and hands, resulting in a loss of nerve conductivity, possibly leading to muscle strength problems (Kate, 1995). The detection, amplification and recording of changes in skin voltage produced by underlying skeletal muscle contraction are called electromyography. The recording obtained is called Electromyogram. The Abductor Pollicis Brevis (APB) is a member of the thenar muscles and is often affected by muscle antropy associated with CTS (Kulick, 1986, Mac-Dermid & Wessel, 2004, Marina *et al.*, 2007). Although many clinical and biomechanical studies address CTS, the electrophysiological properties of the APB muscle are still not well understood (Bland, 2007, Liu *et al.*, 2000, Nobuta *et al.*, 2005, Olmo *et al.*, 2000). EMG signal is a biomedical signal that measures electrical currents generated in muscles during its contraction representing neuromuscular activities. The nervous system always controls the muscle activity (contraction/relaxation). Hence, the EMG signal is a complicated signal, which is controlled by the nervous system and is dependent on the anatomical and physiological properties of muscles (Reaz *et al.*, 2000). EMG is used to detect muscular disorder along with muscular abnormalities caused by other system disease such as nerve dysfunction (Imteyaz *et al.*, 2012). Surface EMG is the more common method of measurement, since it is non-invasive and can be conducted by personnel other than Medical Doctors, with minimal risk to the subject (Day, 2001). The muscle tensile strength or muscle fibres tensile strength related to hand grip movement decreases with age (Delgrosso & Boillat, 1991).

In the present study an attempt has been made to analyse the impact of age on potential CTS symptoms amongst shocker manufacturing assembly line workers through Chi-square test and surface-electromyography (sEMG) signal analysis.

2. Materials and methods

This work was carried out at shocker manufacturing industry in Haryana State, India. 70 workers were included in the study. The number of employees at the studied line was 91. In the present study we excluded those who did not work at the line, those who were off work due to sick-leave, pregnancy, education, chronic illness or due to other reasons. The study included those 70 that were present at their workstation on the day of examination of those specific workstations.

2.1. Methods

The present study was conducted in a shocker manufacturing assembly profile section. The workers were interviewed and examined at the work-site. The health questionnaire was designed and statistical measurements were taken. Verbal consent of the workers was being taken and physical tests have been conducted. The health questionnaire included statistical description, investigation through physical examination, CTS symptom severity scale and on-job observation. Physical examination included height, weight, Body Mass Index (BMI), grip strength (dominant hand) and grip strength (non- dominant hand) measurement in assembly line as shown in Table 1. All physical examinations were being conducted through analog instruments. Readings were noted and tabulated. The descriptive statistics of the parameters with mean and standard deviation were computed and shown in the Table 1. Hand grip strengths of dominant and non-dominant hands were taken so as to find out there relationships with potential CTS symptoms. CTS symptom severity scale is divided into four levels, namely 0, 1, 2 and 3. The level 0 for no, 1 for mild, 2 for moderate, and 3 is for severe CTS symptoms condition. No means zero pain, one means pain in APB muscle. Mild means pain in APB and FPB muscle, moderate means pain in fingers, thenar muscles and hands occasionally, severe means intolerable pain in fingers, thenar muscles, hands, elbow up to shoulder. CTS symptom severity scale has been applied upon potential CTS symptoms namely wrist pain, hand pain, numbness, tingling, difficulty in grasping and weakness to investigate the impact of CTS symptoms. Repetitiveness in the job has been categorized into two levels namely high and low based on cycle time. The physical examination included 4 items namely shoulders, hands, wrist and fingers. The work exposure evaluation was done in two ways; the workers own opinion in the questionnaire and an evaluation by the investigators including an ergonomic study. The whole examination took place in the supervisor’s office, nearby the actual workstation. The results from these sources were compared for each of the operations investigated. Workers at the same workstation did the same job, and there was job rotation every two hours. The standard values of weight of the job and magnitude of the force applied during operations by the workers was provided by the company.

2.2 Statistical Description

The collected data from questionnaire and physical tests is summarized based on age, weight, height, Body Mass Index (BMI), hand grip strength, and job duration in assembly line as shown in Table 1. The descriptive statistics of the parameters with mean and standard deviation have been mentioned in the Table 1.

Table 1: Mean, standard deviation and range of physical variables of shocker manufacturing workers

Sr. No.	Variable	Unit	Mean	Standard Deviation	Range
1.	Age	Years	39.29	7.76	27-56
2.	Height	Meter	1.67	0.072	1.58-1.78
3.	Weight	Kg	67.54	7.91	54-85
4.	BMI	kg/m^2	23.29	0.65	17.60-31.60
5.	Grip strength (Dominant hand)	Kg	52.06	16.57	30-79
6.	Grip strength (Non-Dominant hand)	Kg	49.27	14.72	28-75
7.	Employment time at present site	Years	12.57	7.40	7-28

2.3 Experimental Set up of sEMG

Myoelectric signal represents the electrical activity of muscles and its signal value is represented in milli volts obtained by surface electromyography (sEMG) technique. sEMG signals have been taken by BIOPAC MP-45 data acquisition unit as shown in Figure 1. The MP-45 unit is an electrically isolated data acquisition unit, designed for biophysical measurements. The MP-45 receives power from the computer (USB port). The MP Unit has an internal microprocessor to control data acquisition and communication with the computer. The MP-45 Unit takes incoming signals and converts them into digital signals that can be processed with the computer. There are analog input channels (two on MP-45), one of which can be used as a trigger input. In the present study 70 workers have been examined by the BIOPAC MP-45 instrument. To take readings from the muscles of a subject three electrodes are used. The negative electrode (white) is placed on APB muscle and positive electrode (red) is placed 6 to 10 cm away from negative electrode. The third electrode (black) is grounded. An EMG reading of APB muscle of dominant hand is recorded for 3 minutes (180 sec.) for a series of clenching fists as hard as possible, and then followed by slow release. For uniformity and consistency of sEMG signal value of each worker analysis, the readings have been taken from 150 seconds to 180 seconds. Positions of electrodes are shown in Figure 2 and Figure 3.

Figure 1: sEMG Experimentation Set-up

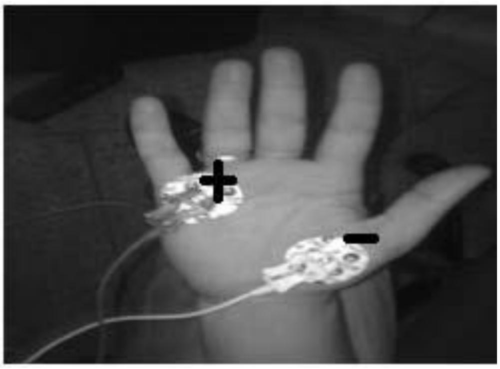

Figure 2: Position of negative and positive electrodes

Figure 3: Position of ground electrode

2.4. Statistical tool for CTS symptoms analysis

Following statistical tool has been used for CTS analysis.

2.4.1 Chi- square test

The chi-square (χ^2) is the most common test due to its significance for relating nominal variables. The purpose of the χ^2 test is to answer the question by comparing observed frequencies with the expected frequencies derived under the hypothesis of independence (Babu & Sanyal, 2009).

The test statistic for χ^2 is expressed as

$$\chi^2 = \frac{\Sigma(f_o - f_t)^2}{f_t} \qquad (1)$$

where f_o is an observed frequency and f_t is the expected frequency of data belonging to concerned workers in present study.

The expected frequencies for the purpose are computed as follows

$$f_t = \frac{(\text{Row total})(\text{Column total})}{\text{Total sample size (N)}} \qquad (2)$$

where total sample size (N) is total number of observations used in the hypothesis.

This test is applicable when the total sample size (N) ≥ 50, for which expected frequency (f_t) should be ≥ 5. The constraints on the cell frequencies if any should be linear i.e. they should not involve square and higher powers of the frequencies such as $\sum f_o = \sum f_t = N$

In the present study Chi- square test is used to check the physical conditions responsible for CTS symptoms in the total set of observations (N).

3. Results and discussions

Factors like probability of CTS symptoms sufferers and age amongst assembly line workers are described in the following sub points.

3.1 Analysis for impact of age on CTS symptoms

To study the impact of age on CTS, data from health surveillance in assembly line workers is classified according to age and potential CTS symptoms. To test the probability of having CTS symptoms is more amongst workers beyond 35 years, a null hypothesis is assumed that the probability of having CTS symptoms is not more amongst workers beyond 35 years.

Observed frequency of survey based CTS data has been classified according to their age taking base age as 35 years as shown in Table 2. From Table 3 it is evident that 61.76% workers beyond 35 years of age whereas 25% of the workers having age less than 35 are CTS symptoms sufferers. Finally χ^2 has been calculated and is given in Table 5.

Table 2: 2 × 2 contingency Table for Chi-square test

Workers	Age>35	Age<35
CTS symptoms subjects	21	9
Control subjects	13	27

Observed, expected and $\chi 2$ calculations have been shown in Table 3, 4 and 5.

Table 3: Observed frequency data

Workers	Age>35	Age<35	Total
CTS symptoms subjects	21	9	30
Control subjects	13	27	40
Total	34	36	70

Table 4: Expected frequencies

Workers	Age>35	Age<35	Total
CTS symptoms subjects	E_1=30x34/70=14.57	E_2=30x36/70=15.43	30
Control subjects	E_3=40x34/70=19.43	E_4=40x36/70=20.57	40
Total	34	36	70

Table 5: Calculated χ^2 values

Observed frequency (f_o)	Expected frequency (f_t)	$(f_o- f_t)^2$	$(f_o- f_t)^2/ f_t$
21	14.57	41.34	2.84
9	15.43	41.34	2.68
13	19.43	41.34	2.13
27	20.57	41.34	2.01
		$\chi^2=\sum(f_o- f_t)^2/ f_t$=9.66	

Degree of freedom (D.O.F) = (r-1) (c-1) = (2-1) (2-1) = 1

Since the calculated value 9.66 of χ^2 is greater than the standard value i.e. 3.84 for degree of freedom 1, the hypothesis is rejected. Hence the probability of having CTS is more amongst workers beyond 35 years.

3.2 Analysis of sEMG signal

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The mean RMS value of EMG signals has been taken from 150 second to 180 second for each worker. All the signal values of sEMG are in milli volts (mV). The wave form of a subject for time interval 150-180 sec is shown in Figure 4. Mean EMG-RMS value (mV) of 70 workers was obtained using BIOPAC MP-45 acqua-knowledge software.

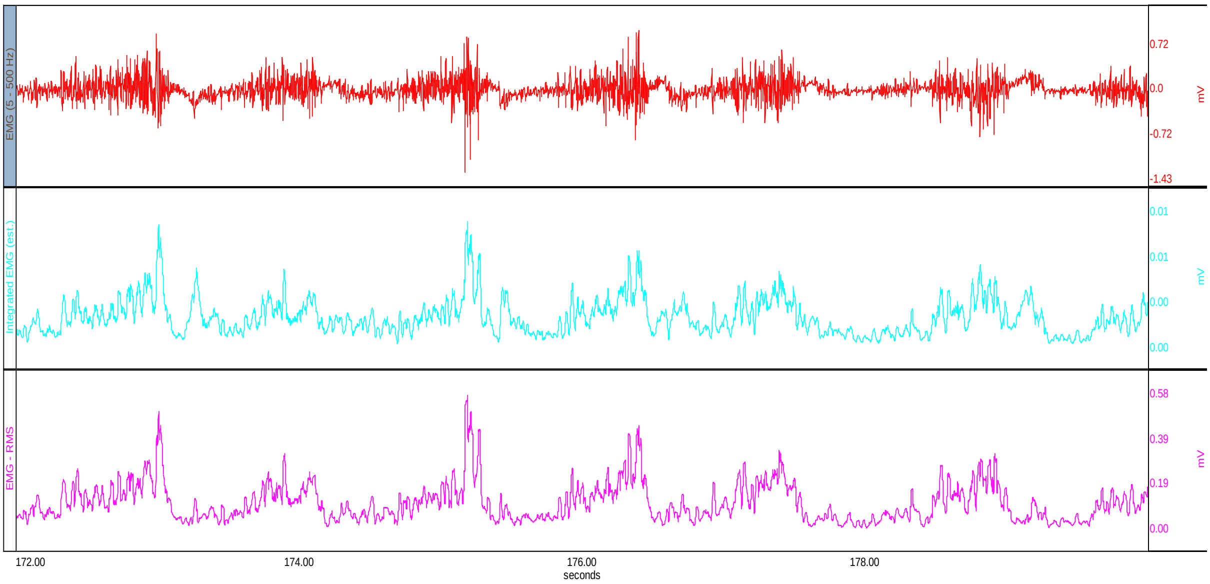

Figure 4: Wave form of a subject for time interval 150-180 sec.

Average values of 70 mean EMG-RMS were calculated on the basis of age and CTS symptoms occurrence in Table 6.

Table 6: Mean EMG-RMS value of assembly line workers

Workers	Age>35	Age<35
CTS symptoms subjects	0.01171	0.01804
Control subjects	0.16538	0.36897

Average of mean EMG-RMS values of workers having CTS symptoms was found to be lower than the value of control subjects. Hence, lower muscle activity amongst workers having potential CTS symptoms confirms the presence of CTS symptoms.

4. Conclusion

The chi-square test result reveals that probability of having CTS symptoms is more amongst workers beyond 35 year's of age. Data indicates that 61.76% workers beyond 35 years of age whereas 25% of the workers having age less than 35 are CTS symptoms sufferers. This may be due to the passage of age blood vessels may be damaged leading to poor circulation, slowing down the capability of hand grip, grasping strength contributing to CTS symptoms. The sEMG signal analysis result reveals that the lesser muscle activity (EMG-RMS) values indicate the contribution of CTS symptoms in shocker assembly line workers.

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A Brief Authors Biography

Prof.M.Muralidhar was born in a village in Vijayanagaram dist, Andhra Pradesh, India in the year 1958. He has been working as a professor of Mechanical Engineering and Dean (Planning & Development) of North Eastern Regional Institute of Science and Technology, Itanagar, Arunachal Pradesh, India. He has around 23 years of teaching, and research experience in NERIST, Deemed University. Prior to Joining NERIST he worked in Automobile industry and Steel industry for a period of nine years. He has guided a few Ph.D. and M.Tech. theses. He has published more than 85 papers in reputed Journals and Conferences. He visited Russia, Japan, South Korea, Bangladesh, Slovenia and P.R.China for presenting papers.

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