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Analysis for prevalence of carpal tunnel syndrome in shocker manufacturing workers

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A B S T R A C T

Carpal tunnel syndrome (CTS) is the most commonly reported work-related musculoskeletal disorder of the upper extremity. In this communication, a comparison of CTS and associated risk factors amongst traditional and semi-ergonomic shocker manufacturing assembly line workers in the actual industrial environment has been studied through questionnaire and physical tests. Fisher's exact test and Surface electromyography (sEMG) signal values have been used for statistical data analysis. Symptoms present are numbness (in 80 % of traditional and in 16.66 % of semi-ergonomic), tingling (in 50 % of traditional and in 8.33 % of semi-ergonomic), and difficulty in grasping (in 80 % of traditional and 20 % of semi-ergonomic). Tinel's and Phalen's sign also show an almost similar trend. The results reflect that the traditional shocker manufacturing workers have more CTS symptoms occurrence than the semi-ergonomic shocker manufacturing workers. 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. It is found that there is a significant difference in EMG-RMS values of CTS symptoms and control subjects in traditional and semi-ergonomic shocker manufacturing industries. It is observed that if a subject is affected with CTS symptoms, then the sEMG signal value is 0.01223 mV in case of traditional and 0.02625 mV in case of semi-ergonomic shocker assembly, and for control subjects sEMG signal value is 0.15614 mV in traditional and 0.17563 mV in case of semi-ergonomic shocker assembly.

A R T I C L E I N F O

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1. Introduction

Occupational health problems, injuries and disorders are primarily due to the work characteristics and environment in industries worldwide [1, 2]. Research survey on Repetitive Strain Injuries (RSI) has been observed as the most common form of work related illness of physical and psychological affecting various organizations [3-6]. RSI directly affect the quality and production rate of work, health of workers, work satisfaction, and absenteeism [7-10]. One of the common RSI Carpal Tunnel Syndrome (CTS) and associated risk factors among assembly line workers engaged in traditional and semi-ergonomic shocker manufacturing industries are due to work-related musculoskeletal disorders (WMSDs). Assembly line workstations and their operations are executed repeatedly and hence result WMSDs [11, 12]. Musculoskeletal disorders (MSDs) means conditions associated with the upper extremities (arm and hand) affecting the muscles, nerves or other soft tissues, tendons, ligaments, and joints. MSDs are common occupational diseases among assembly line workers due to repetitive movements or heavy workloads [13, 14].

The assembly line workers of automotive industry are one of several industries that have high incidence of MSDs [15, 16]. The common risk factor may possible be the repetitive awkward posture of the worker relative to the work while trying to access different tasks in automotive assembly line. Previous studies for automotive industry workforce have shown that awkward postures increase the risk of MSDs [17-19]. Published literature indicate that reducing workplace exposure to known risk factors including awkward posture results in reduced MSD risk [20-22]. The Ovako Working Posture Analysis System (OWAS) method using 3D simulation to identify and evaluate harmful working posture was carried out [23]. CTS is one of the type of MSDs affects 1 % of general population and 5 % of working population undergoing repetitive movements of wrists and hands in daily living. CTS is a narrow tunnel in the wrist formed by ligament and bone. The common symptoms of hand pain, wrist pain, numbness, tingling, and pain within the median nerve were analysed [24, 25]. Investigation on carpal tunnel and osteofibrotic tunnel surrounded by carpal bones and the strong transverse carpal ligament was done. Nine tendons run through the tunnel, as well as the median nerve, which is the closest to the surface, and the associated blood vessels. CTS occurs when the ligaments running through the carpal tunnel get inflamed due to relatively small yet lasting or repeated pressure or vibration, which causes swelling of tendon sheaths resulting in elevated pressure in the carpal tunnel and hence entrapment of the median nerve against the transverse carpal ligament [26]. Studies on CTS by over-worked, over-strained muscles of arms and hands, possibly leading to muscle strength problems were carried out [27].

A review on long exposure to repetitive flexion and extension of the wrist studies were analysed and the diagnostic procedure were highlighted [28]. The detection, amplification and recording of changes in skin voltage produced by underlying skeletal muscle contraction are termed as electromyography and recording obtained is called Electromyogram. The Abductor Pollicis Brevis (APB) and its affect by muscle entropy associated with CTS were discussed [29-31]. Many clinical and biomechanical studies on CTS, the electrophysiological properties of the APB muscle were investigated [32-35]. EMG signal is a biomedical signal that measures electrical currents generated in muscles during its contraction and expansion representing neuromuscular activities. The nervous system always controls the muscular activity. The analysis of EMG signal and physiological properties of muscles was carried out [36]. Study on EMG to detect muscular disorder along with muscular abnormalities caused by other system disease such as nerve dysfunction was done [37]. Investigation on surface EMG and its use by personnel other than medical doctors was carried out [38]. Studies on anthropometric characteristics of the hand, muscle tensile strength related to hand grip movement was carried out [39]. Several studies confirmed persons with high BMI to be a group at high risk for developing CTS. High BMI is also associated with decreased sensory conductivity of the median nerve [40-43].

In the present study an attempt has been made to monitor the impact of CTS and associated risk factors in traditional and semi-ergonomic shocker manufacturing industries through Fisher's exact test and sEMG signal analysis.

2. Materials and methods

This work was carried out at two shocker industries in Haryana State, India. 140 workers of two shocker manufacturing industries, one is based on traditional and other on semi-ergonomic standards, were included in the study. In traditional shocker assembly all parts are assembled manually and some operation by machines (like cylinder bottom pressing, cylinder valve tightening with the help of riveting machine) are performed on an assembly line. Semi-ergonomic shocker assembly is a system of using machines considering human machine interface and ergonomical aspects for assembly of shock absorber. There are 70 workforce in traditional, with a mean age of 39.29 ± 7.76 years, range 25-56, and 70 in semi-ergonomic, with a mean age of 29.23 ±3.54 years, range 23-40. The number of workers at the studied line was 91 in traditional and 85 in semi-ergonomic. 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 140 that were present at their workstation on the day of examination of those specific workstations. The full questionnaire is shown in the Appendix A.

2.1 Shock absorber operations and assembly systems

The ergonomics study has been conducted on total 140 workers of two shocker manufacturing industries. One is based on traditional and other on semi-ergonomic standards having manual operations such as case tube cleaning, cylinder cleaning, component cleaning, guide disk assembly, piston valve tightening/riveting, cylinder bottom valve assembly/tightening, oil filling in cylinder, cylinder bottom pressing, piston rod circlipping, oil seal assembly, oil seal pressing and beading and Sealing. A brief description of each operation is given below.

Case tube cleaning

In this operation the outer tube is cleaned extensively so that the shocker can work properly. It is made up of mild steel and having weighs around 2 kg. The operation is performed in a cleaning chamber with a suitable brush in both the industries.

Cylinder cleaning

To remove foreign particles properly from outer surface of cylinder the phosphate solution is used. In semi-ergonomic industry both case tube cleaning and cylinder cleaning operations are performed at same work station as shown in Fig. 1.

Fig. 1 A typical photograph of case tube and cylinder cleaning event at traditional and semi-ergonomic shocker assembly line

Component cleaning

Small components like bush, washer and oil seal are cleaned in a tray by the air pressure to wipe out the dust and foreign particles properly. The number of operators engaged in traditional shocker assembly unit are five whereas in semi-ergonomic industry are four. In both the industries the operation was performed in cleaning chamber as shown in Fig. 2.

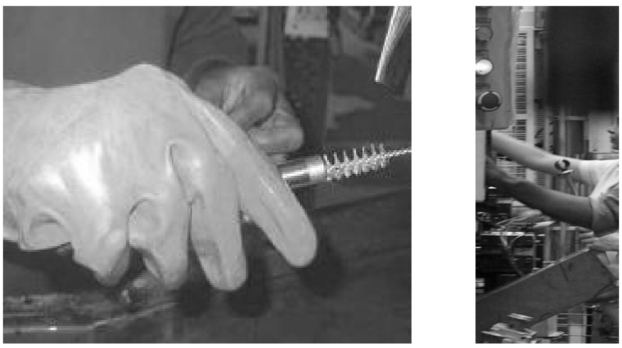

Fig. 2 A typical photograph of component cleaning event at traditional and semi-ergonomic shocker assembly line

Guide disk assembly

In this operation guide disk is used for piston and main spring support. The assembly is done by spanner and air nut runner. The four numbers of operators are engaged in traditional and semi-ergonomic industries. In traditional manufacturing unit, the operation is performed by a conventional spanner at guide disk assembly station whereas in semi-ergonomic industry, it is performed on a moving conveyor by air nut runner as shown in Fig. 3.

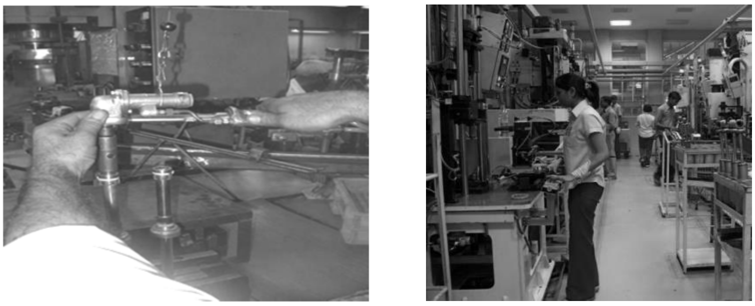

Fig. 3 A typical photograph of guide disk assembly event at traditional and semi-ergonomic shocker assembly line

Piston valve tightening/riveting

In both the industries, the operation is performed by a riveting press at piston valve tightening station. The operation is performed on moving conveyor and piston valve is tightened by riveting machine. The number of operators engaged is five in both the industries as shown in Fig. 4.

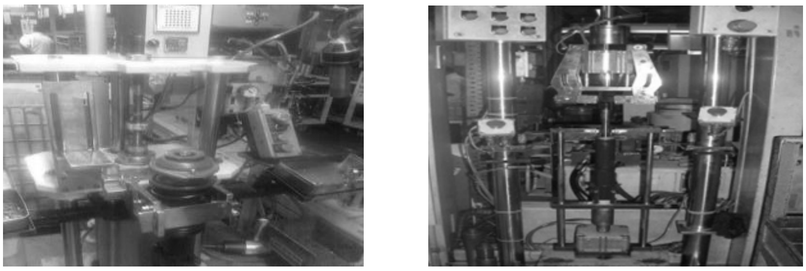

Fig. 4 A typical photograph of piston valve tightening event at traditional and semi-ergonomic shocker assembly line

Cylinder bottom valve assembly/tightening

In both the industries, the operation is performed at cylinder bottom valve assembly station and cylinder bottom valve is tightened by riveting press. The operation is performed on a moving conveyor and piston valve is tightened by air nut runner. The number of operators engaged in traditional and semi-ergonomic industries is four and five respectively as shown in Fig. 5.

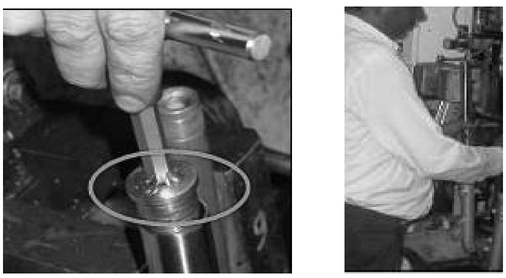

Fig. 5 A typical photograph of cylinder bottom valve assembly event at traditional and semi-ergonomic shocker assembly line

Oil filling in cylinder

For friction control the lubricant oil is poured manually in the cylinder in traditional manufacturing unit whereas in semi-ergonomic industry, it is done by oil filing machine. Number of operators engaged in traditional and semi-ergonomic industry is five and three respectively as shown in Fig. 6.

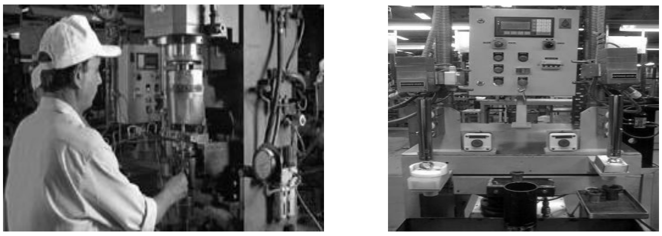

Fig. 6 A typical photograph of oil filling event at traditional and semi-ergonomic shocker assembly line

Cylinder bottom pressing

In this operation, after tightening the cylinder bottom valve, cylinder bottom is pressed by five tonnage presses. In traditional industry four operators are engaged whereas in semi-ergonomic industry three operators are engaged as shown in Fig. 7.

Fig. 7 A typical photograph of cylinder bottom pressing event at traditional and semi-ergonomic shocker assembly line

Piston rod circlipping

In traditional industry the operation is performed with the help of conventional spanner whereas in semi-ergonomic industry the operation is performed by air nut runner. The operator engaged in this operation is four in both the industries as shown in Fig. 8.

Fig. 8 A typical photograph of piston rod circlipping event at traditional and semi-ergonomic shocker assembly line

Oil seal assembly

Oil seal prevents the oil leakage from cylinder during movement of piston in cylinder. In this operation oil seal is assembled to the top of cylinder. It contains rubber seal, valve inlet and a nut which is assembled manually with the help of spanner in both industries. The operators engaged in this operation are five in both the industries as shown in Fig. 9.

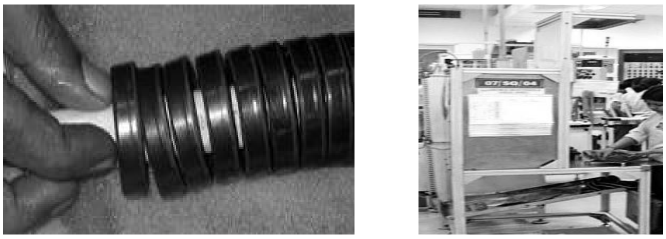

Fig. 9 A typical photograph of oil seal assembly event at traditional and semi-ergonomic shocker assembly line

Oil seal pressing

In this operation, oil seal assembly is pushed with the help of a riveting machine in both the industries. The number of operators engaged in the operation is five in both the industries as shown in Fig. 10.

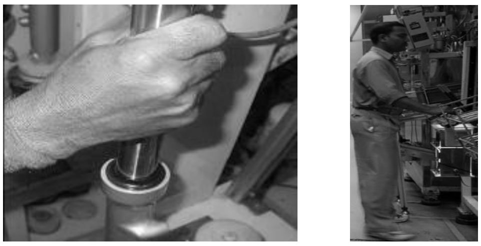

Fig. 10 A typical photograph of oil seal pressing event at traditional and semi-ergonomic shocker assembly line

Beading and sealing

In beading operation, the casing chamber of shocker is closed with special purpose machine called beading machine. In traditional manufacturing unit, five operators are engaged. The sealing operation is similar to beading operation but it is performed on a similar kind of special purpose machine, for the enforcement of beading joint to ensure the leakage of hydraulic oil and air in the casing tube chamber. In semi-ergonomic industry, the beading and sealing operation is performed on the same machine and total eleven operators are engaged in this combined task as shown in Fig. 11 and Fig. 12.

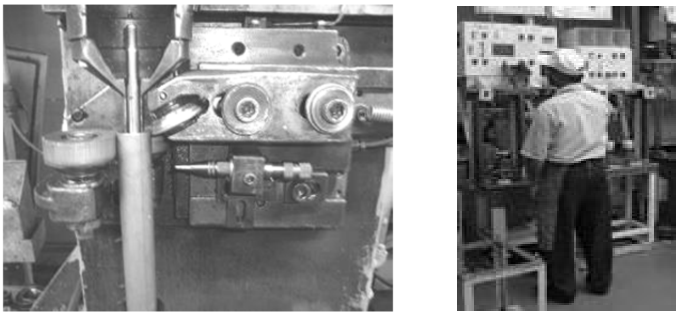

Fig. 11 A typical photograph of beading event at traditional and semi-ergonomic shocker assembly line

Fig. 12 A typical photograph of sealing event at traditional and semi-ergonomic shocker assembly line

2.2. Methods

The study was conducted at two shocker manufacturing plants. The companies provided a list of all jobs in the facility. The present study was conducted in traditional and semi- ergonomic 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, BMI, and grip strength 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 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 Abductor Pollicis Brevis (APB) muscle. Mild means pain in APB and Flexor Pollicis Brevis (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.

2.3 Statistical description

The collected data from questionnaire and physical tests is summarized based on age, weight, height, 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 Statistics of two shocker manufacturing assembly line workers

Factor of concern	Traditional shocker manufacturing workers (Mean ± S.D.)	Semi-ergonomic shocker manufacturing workers (Mean ± S.D.)
Number	70	70
Age (years)	39.29 ± 7.76	29.23 ±3.54
Weight (kg)	67.54 ± 7.91	64.33 ± 5.60
Height (m)	1.667 ± 0.072	1.664 ± 0.067
BMI (kg/m^2)	23.29± 0.65	23.18 ± 0.59
Grip strength (kg)	42.06 ± 16.57	50.67 ± 18.83
Employment time at present site (years)	12.57 ± 7.40	4.57 ± 3.08

2.4 Experimental set up of sEMG

Myoelectric signal represents the electrical activity of muscles and its signal value is represented in millivolts obtained by surface electromyography (sEMG) technique. sEMG signals have been taken by BIOPAC MP-45 data acquisition unit as shown in Fig. 13. 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 140 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 180 s for a series of clenching fists as hard as possible, and then followed by slow release. Low voltage stimulator, electrodes and electrode lead set are shown in Figs. 14, 15, and 16.

Fig. 13 EMG Experimentation set-up

Fig. 14 Low voltage stimulator

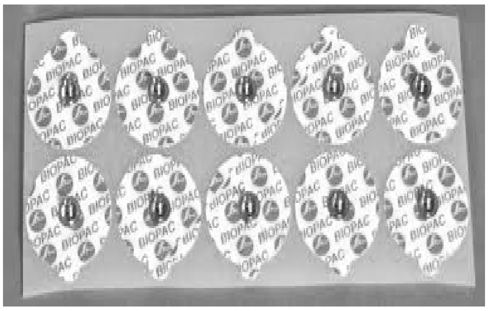

Fig. 15 Electrodes

Fig. 16 Electrode Lead Set

2.5. Statistical tool for CTS analysis

Following statistical tool has been used for CTS analysis.

Fisher's exact test

Fisher's exact test is used to check statistical significance of 2×2 contingency Tables. In present study Fisher's exact test has been used to check all the symptoms of CTS in collected data of traditional and semi-ergonomic industries workers for comparison on the basis of response of workers for all the symptoms in yes or no. Notations *a*, *b*, *c* and *d* are assigned to cells for fisher's exact test and the grand total is assigned the notation *n* and are presented in Table 2.

Table 2 A 2 × 2 contingency table set-up for Fisher's exact test

Description	Traditional shocker manufacturing worker	Semi-ergonomic shocker manufacturing worker	Total
Symptom present (Test positive)	a	b	$a + b$
Symptom not present (Test negative)	c	d	$c + d$
Total	$a + c$	$b + d$	n

The probability value p is computed by the hyper geometric distribution and expressed as

$$p = \frac{\binom{a+b}{a}!\binom{c+d}{c}!}{\binom{n}{a+c}!} = \frac{(a+b)!\,(c+d)!\,(a+c)!\,(b+d)!}{a!\,b!\,c!\,d!\,n!} \tag{1}$$

where the number of observations obtained for analysis is small (sample size ≤ 30) [44].

3. Results and discussions

3.1 CTS symptoms based analysis by Fisher's exact test

The CTS symptoms like hand pain (pain is felt in the part of upper extremity distal to wrist joint), wrist pain (pain is felt in between distal portion of forearm and proximal portion of hand), numbness (loss of sensation), tingling (sensation of having sharp object pressure on affected area), difficulty in grasping (inability of holding any object in palmer aspect of hand properly), weakness (lack of strength to do a particular job), Tinel's sign, and Phenal's sign in traditional and semi-ergonomic shocker manufacturing workers with their percentage of presence are computed from the collected data and Eq. 1. The p-value so obtained is used to check the significance of the symptoms as shown in Table 3.

Table 3 Test of difference between traditional and semi-ergonomic shocker manufacturing workers considering CTS related symptoms, and by applying Fisher's exact test

Symptoms	Traditional shocker manufacturing worker			Semi-ergonomic shocker manufacturing worker			p-value	Significance
	No. of workers	CTS symptoms sufferer	%	No. of workers	CTS symptoms sufferer	%		
Hand pain	10	2	20	5	1	20	0.4945	Not significant
Wrist pain	12	1	8.33	3	1	33.33	0.3428	Not significant
Numbness	5	4	80	12	2	16.66	0.0266	Significant ($P < 0.05$)
Tingling	10	5	50	12	1	8.33	0.0405	Significant ($P < 0.05$)
Difficulty in grasping	5	4	80	10	2	20	0.0449	Significant ($P < 0.05$)
Weakness	7	1	14.2 8	3	1	33.33	0.4660	Not significant
Tinel's sign	12	8	66.67	11	2	18.18	0.0237	Significant ($P < 0.05$)
Phenal's sign	9	5	55.55	14	2	14.28	0.0467	Significant ($P < 0.05$)

From the Table 3 it is observed that due to difficulty in grasping problems 80 % of traditional and 20 % of semi-ergonomic shocker manufacturing workers ($p < 0.05$), have been unable to perform the usual activities. The data analyzed from questionnaire also show that traditional shocker manufacturing workers have more percentage of CTS symptoms like numbness, tingling, Tinel's and Phalen's sign. Tinel's sign occurred in 66.67 % of the traditional and 18.18 % of the Semi-ergonomic shocker manufacturing workers ($p < 0.05$). Phalen's sign also show almost similar trend. Hand pain, wrist pain and feeling of weakness cannot correlate to CTS in the present study, as these are recognized as insignificant by Fisher's exact test. The results reflect that the traditional shocker manufacturing workers had more CTS symptoms occurrence than the Semi-ergonomic shocker manufacturing workers.

3.2 Analysis of sEMG signal

The mean RMS value of sEMG signals has been taken from 10-40 s for each worker. All the signal values of sEMG are in millivolts (mV). The sEMG signal graph of a worker for time interval 20-24 s in traditional and semi-ergonomic shocker assembly line is shown in Fig. 17 and Fig. 18. The wave form of a subject is shown in Fig. 19. Mean EMG-RMS value (mV) of 140 workers was obtained using BIOPAC MP-45 acqua-knowledge software. From the sEMG data the values of Raw-

EMG, Integrated-EMG and Root-mean square EMG are obtained. The Raw-EMG is the unprocessed signal of amplitude between 0-6 mV measured from peak to peak and represents the amount of muscle energy measured. Raw-EMG signal helps mostly in qualitative analysis. Integrated-EMG is the calculation of area under the rectified signal. Values are summed over the specified time then divided by the total number of values. Values will increase continuously over time. It quantifies the muscle activity. Root-mean square EMG (EMG-RMS) values are calculated by squaring each data point, summing the squares, dividing the sum of squares by number of observations, and taking the square root and it represent the quantification of muscle activity.

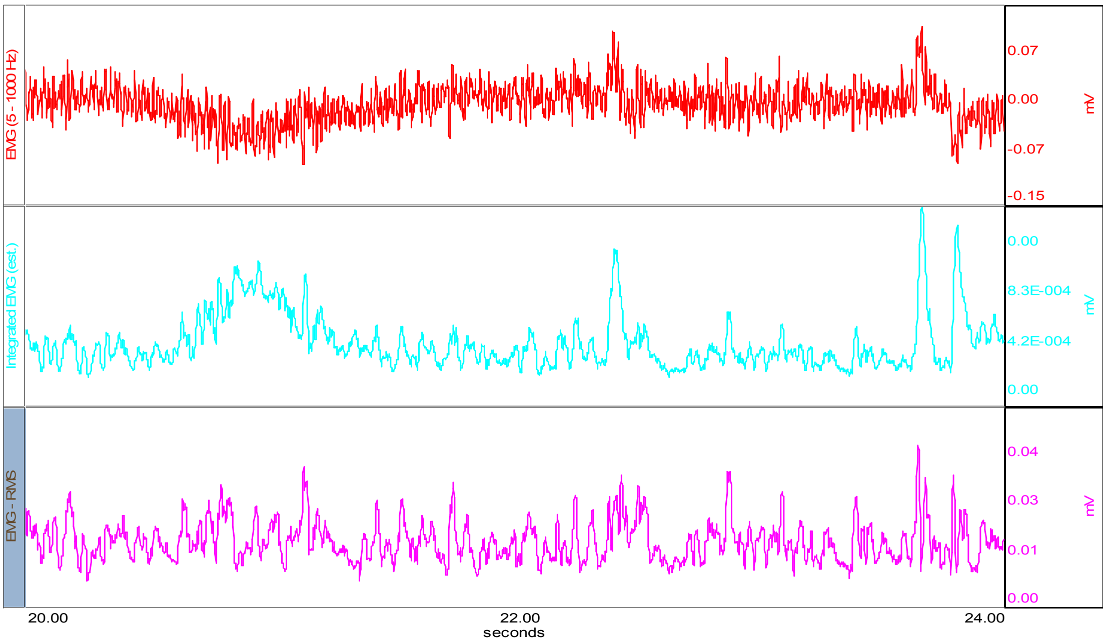

Fig. 17 sEMG signal graph of a worker for time interval 20-24 s in traditional shocker assembly line

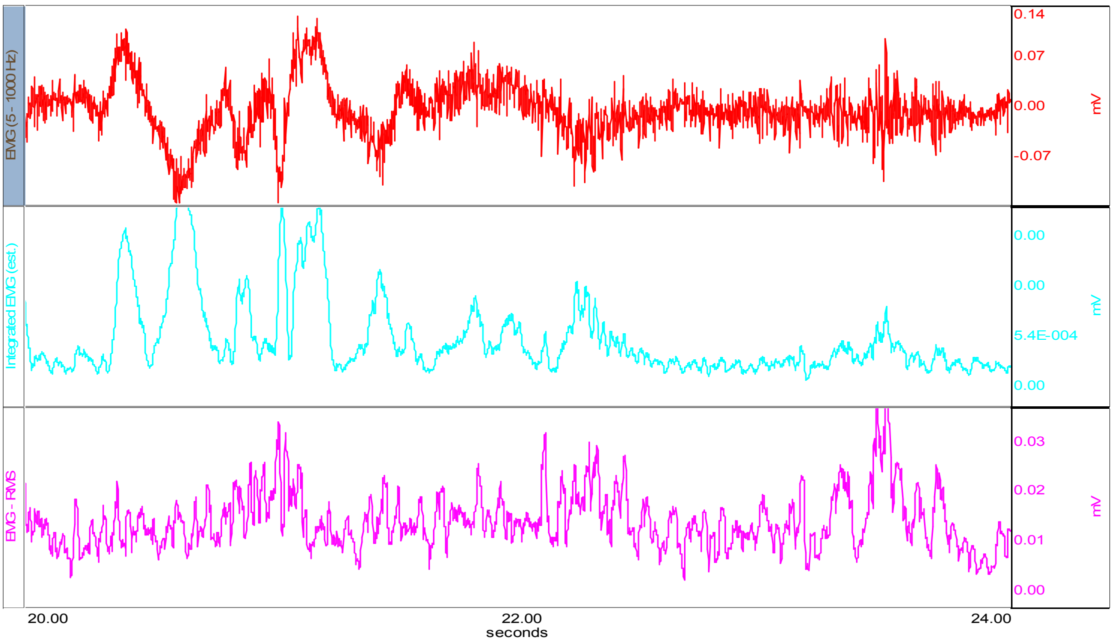

Fig. 18 sEMG signal graph of a worker for time interval 20-24 s in semi-ergonomic shocker assembly line

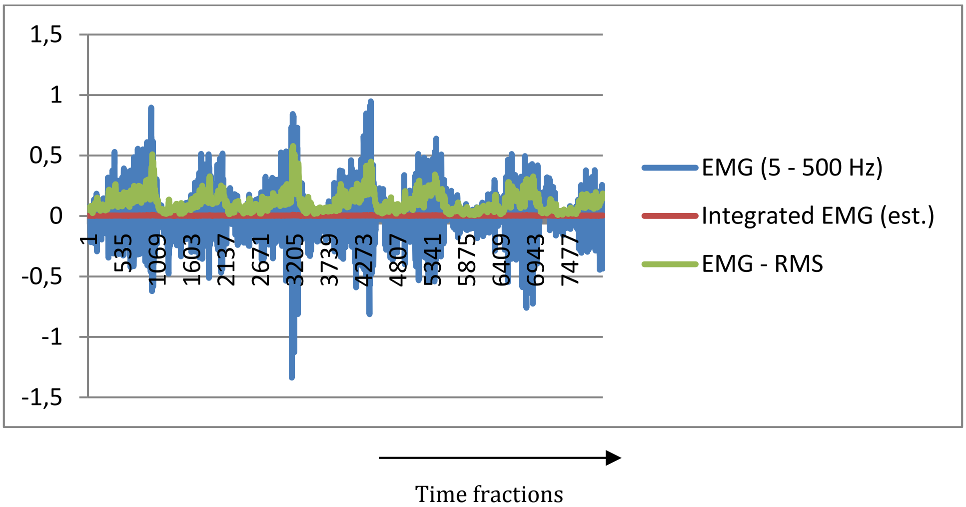

Fig. 19 Wave data graph of shocker manufacturing worker for time interval 20-24 s

Mean EMG-RMS value were calculated on the basis of CTS symptoms occurrence in traditional and semi-ergonomic shocker manufacturing assembly line workers as shown in Table 4. 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.

Table 4 Mean EMG-RMS value of shocker assembly line workers

Workers	CTS symptoms subjects	Control subjects
Traditional shocker assembly	0.01223	0.15614
Semi-ergonomic shocker assembly	0.02625	0.17563

4. Conclusions

The results elicit that CTS symptoms are present among the workers engaged in shocker assembly line doing the repetitive job. It has been observed that traditional shocker manufacturing workers are more at risk of CTS symptoms occurrence than the semi-ergonomic shocker manufacturing workers. Positive Tinel's sign occurred in 66.67 % of the traditional and 18.18 % of the semi-ergonomic shocker manufacturing workers. Positive Phalen's sign occurred in 55.55 % of the traditional and 14.28 % of the semi-ergonomic shocker manufacturing workers. Difficulty in grasping occurred in 80 % of the traditional and in 20 % of the semi-ergonomic shocker manufacturing workers. The study also shows 50 % of cases of tingling in traditional shocker manufacturing workers as compared to 8.33 % of semi-ergonomic shocker manufacturing workers. This may be due to more involvement of manual repetition, awkward posture and stressful exertion in traditional manufacturing industry as compared to semi-ergonomic industry. 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. It is observed that if a subject is affected with CTS symptoms then sEMG signal value is 0.01223 mV in case of traditional and 0.02625 mV in case of semi-ergonomic shocker assembly and for control subjects sEMG signal value is 0.15614 mV in traditional and 0.17563 mV in case of semi-ergonomic shocker assembly. The lesser EMG-RMS value of CTS symptoms subjects may be due to the muscular disorder and abnormalities caused by nerve dysfunction.

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Appendix A

North Eastern Regional Institute of Science and Technology
(Deemed University, Nirjuli, Arunachal Pradesh, Established by Government of India)

To study Carpal Tunnel Syndrome (CTS) among personnel in shocker manufacturing plants

GENERAL INFORMATION

Name:	Date:
Age:	Email Id:
Gender:	Contact No.:
Employers Name/Company:	Occupation:
Main functional areas of job, Major tools, equipment machinery used in performing job Previous diagnosis of a musculoskeletal disorder	Level of education Previous wrist Fracture

Repetitive task in job	Cycle time	Weight	R/L/Both	h/Day	Bending	Breaks	Partially/whole body vibration

Hand grip strength (kg) LH	Shoulder strength (kg) (push + pull) RH
Weight:	Push:
Height:	Pull:
Do you fell the job is of repetitive nature : Yes ( ) (if Yes specify the rating) _____/s _____/min _____/h	No ( )

WORK SYMPTOM SEVERITY SCALE

INSTRUCTIONS: The following questions refer to your symptoms during the past two weeks (circle one answer to each question)

	Wrist pain	**Hand pain**	**Numbness**	**Tingling**	**Difficulty in grasping**	**Weakness**	**Tinel's sign**	**Phalen's sign**
Case tube cleaning	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4
Cylinder cleaning	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4
Component cleaning	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4
Guide disk assembly	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4
Cylinder bottom pressing	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4
Oil filling in cylinder	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4
Cylinder bottom valve assembly	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4
Piston valve/ Tightening/ Riveting	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4
Piston rod circlipping	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4
Oil seal assembly	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4
Oil seal pressing	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4
Beading and sealing	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4

How long have you been in the present job?
Describe some difficulties in performing the job like – lack of concentration, focusing problem, depression due to CTS prone job etc.

0 = No, 1 = Mild, 2 = Moderate, 3 = High, 4 = Severe

Personal Risk Factors (Yes/No)	Occupational Risk Factor (Yes/No)
1) Diabetes/BP/Heart problem/asthma 2) Hand preference 3) Obesity and lack of sport 4) Grasp with force 5) Turn and screw 6) Arm above the shoulder 7) Use of vibrating tools	1) Manual material handling 2) Frequent bending and twisting 3) Heavy physical load 4) Static work posture 5) Whole body vibration 6) Force applied 7) Localized mechanical compression 8) Awkward posture 9) Working in cold environments 10) Working with cold hands