Study on Discomfort in Mobile Crane Operation

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Abstract - *The study tends to confirm that the operators of the mobile cranes experience musculoskeletal discomfort at elevated rates to the low back, neck, and shoulders. The results of the discomfort study revealed that uncomfortable features of the cabin is associated with the risk of adverse health effects on neck, right shoulder and lower back. 9-75 tonnes capacity and 3-35 years old seven different make cranes were taken for the study. During the operation 20 operators were observed in different shifts, all operators are expressed that the most uncomfortable part is neck as the load has to be observed very keenly during handling . The next most discomfort level is shoulder (70.9%) and lower back (60%). Frequency of reported discomfort over a week, 1 or 2 Times 30%, 3 or 4 Times 35%, Every Day 15% and Several times a Day 20%. Out of seven different make mobile cranes studied, the highest acceptance level of the cabin is 70.97% but the discomfort level of neck 60% lower back 50% and shoulder 57.14% is recorded in the crane. It is concluded that the cab of mobile crane have to be improved to reduce the occurrence of the musculoskeletal disorders, modification of cab characteristics that can enhance the overall safety and health of the operators.*

Key Words: Mobile Crane, Discomfort, Ergonomics, Musculoskeletal disorders, Frequency, Intensity.

1. INTRODUCTION

Driving and handling of materials in the mobile crane is a complex task which requires execution of physical, psycho-motor, and sensory skills. To ensure maximum performance of the operator and for safe operation of the vehicle, optimal driver–vehicle interaction (DVI) is of utmost necessity. Mobile Cranes add a complex dimension to the normal working environment. There are many hazards including ergonomic hazards that are affecting the operator's health and safety. Ergonomic hazards will have both physiological and psychological effects on the operator's health which can further disturb his safety at the workplace, the ergonomic design of the cabin is very much important at this juncture. An ergonomic cabin is required so that the mobile crane operator can sustain under extreme circumstances. Seat of driver should be ergonomically designed according to the contours of human body and head restraint so that it could provide necessary support to head & neck and leads to decreases the chance of injury. (Ankit Jhinkwan et.al 2015)[1] Musculoskeletal disorders are the most complaints among the operators which are again the result of the ergonomic hazards and the poor design of the crane cabin. Because of the musculoskeletal disorders the operators are facing many problems which include fatigue and discomfort which finally can result in the injury and even disability. Lower back, knee, neck and ankle troubles are more prevalent in auto rickshaw drivers increasing age, work experience, maximum working hours per week, increased left shoulder to handle distance and greater driver seat vibrations are increasing the risk of MSD and restricted lower cabin space and reduced shoulder to handle distance on right side also increasing the risk of musculoskeletal disorder Rahul Shaik et.al (2012)[2].

Mobile crane operators are continuously confronted with new challenges and dangers as their work progresses. In a typical industrial setting, workers are exposed to the same environment and hazards every day. The crane cabin design also affects the operator's health and safety. Different crane cabin characteristics cab design characteristics that are more structural in nature, such as seat characteristics (e.g., back and lumbar support, adjustable, tilt capability), armrest characteristics (e.g., are they present, adjustable, etc.), and egress means are to be considered in the design. Poorly designed driver seat affects the driver health and psychological condition of mind (Hanumant N et al, 2015)[3]. It has been found that the taxi cabs used in Nigeria for public transport exists in several variety of models sourced from advanced countries. These vehicles evidently were designed without due consideration for the peculiarities of anthropometric variable of Nigeria user population (Onawumi, A. S et al., 2012)[4]. The automotive industry strongly encourages research in the field of objective comfort assessment, of seat and the related postures (Gyi, D. E., Porter, et al 1998)[5]. Some other important factors that should be considered in the design of in-vehicle elements are related to human body dimensions of the drivers particularly in designing of automobile seat, dashboard, steering wheel, pedals, knobs, levers, and doors (Onawumi, A. S et al.02012)[6]. Work of driver is highly stressful and many factors like prolonged sitting, whole body vibration etc. make taxi drivers distinct from other professions in terms of exposure to risks of work related musculoskeletal disorder. (Saumya et al-2012)[7]. Poor body posture and inadequate seat support have been described as cofactors in the pathogenesis of MSD of the spine in operators (Burdorf. 1992)[8]. Seating discomfort can be highly subjective as different people may assess it differently based on factors like environment, the nature of the task at hand and other internal conditions (O.O. Okuribido, et al 2007)[9]. Performance was reduced when drivers were in an uncomfortable seat in the presence of vibration. (Wassim El Falou et.al-2003)[10].

Though the use of the mobile cranes have solved many problems in handling the heavy loads in all of the work situations the crane operation adds an another complex dimension to the workplace environment which can effect crane operators' health and safety. The aim of the project is to relate the discomfort level of the mobile crane operator and individual muscle strain to their psychological effect. To meet the aim, discomfort assessment was carried out with the mobile crane operators who are the subjects of the study.

1.1 Mobile Crane

Cranes are a generally used for material handling in all industries. Cranes are of many types vis. EOT, Gantry, Mono rail, Jib, Tower, Mobile cranes etc., here mobile crane is taken for study. Mobile crane is a) used primarily for raising or lowering a freely suspended load; b) capable of travelling without the need for fixed runways and c) relies only on gravity for stability. Mobile crane operation mainly involves the a)motion controls- Marching lever, Swinging lever, Brake b) Lifting controls- Boom control, Hook control. The mobile cranes are two types a) Crawler mounted and b. truck mounted. Though the truck mounted crane is having a drivers cabin for movement, a separate cabin is available for the crane operation. Fig. 1,2,3,4 shows the crane operation.

Fig -1: Mobile crane cabin

Fig -2: Mobile crane foot pedal, hand lever

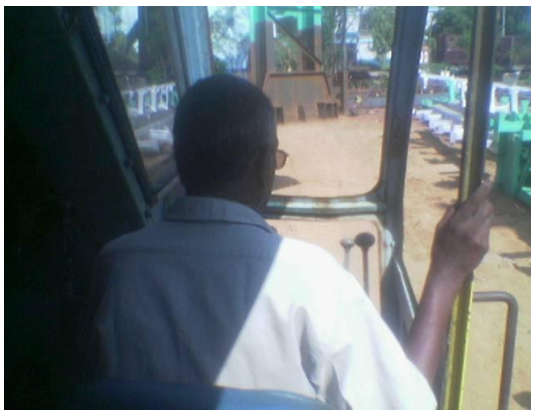

Fig -3: Mobile crane operation1

Fig -4: Mobile crane operation2

Table -1: Mobile Crane Details and cabin dimensions

Mobile Cranes				Cabin Dimensions in Cm					
Sl. No.	Make	Capacity (tonnes)	Age (years)	1	2	3	4	5	6
1	Tata P&H 955 alc	75	35	60	105	45	40	60	44
2	Tata P&H 320	12	35	55	90	38	40	35	38
3	Fmc link belt	35	15	56	102	47	47	42	50
4	Rowther cranes	40	25	57	100	50	43	54	47
5	Coles krane lh300	35	13	50	90	43	41	42	45
6	Ace cranes	9	3	50	80	37	35	23	35
7	Grove cranes	30	20	38	105	44	50	25	70

Table -2: Mobile Crane Seat, Brake and Pedal dimensions

Cranes		seat centre to controls in Cm			seat centre to brake/pedals in Cm	
Sl. No.	Make	7			8	9
		a	b	c		
1	Tata P&H 955 alc	27	15	17	80	105
2	Tata P&H 320	66	66	66	85	110
3	Fmc link belt	53	53	53	95	90
4	Rowther cranes	80	70	76	82	76
5	Coles krane lh300	54	54	54	60	100
6	Ace cranes	60	50	50	75	90
7	Grove cranes	65	58	60	85	75

The basic details required for all the cranes are taken, on which twenty operators are working. The details comprise of seat height(1), total height(2), seat width(3), seat length(4), backrest height(5), backrest width(6), seat centre to controls(7): a=control 1, b=control 2, c=control 3, seat centre to brake/pedals(8), seat centre to the window(9). All the measurements are taken in centimeters and shown in Table 1 and 2.

1.2 Subjects

Though there are number of drivers available for industrial trucks, lorries and busses but mobile crane operators are very limited since the mobile cranes are less. Twenty operators participated in this study. The operators are divided into three groups based on their age worked in two shifts operation. (Table 3)

Table 3 Details of mobile crane operators Age group wise

Age Group years	Number (%)	Parameter	Minimum	Maximum	Mean	Standard Deviation ±
<40	10 50	Age years Height Cm	21 155	33 170	26 164	3.52 5.5
41-50	5 25	Age years Height Cm	43 167	49 179	46.2 167.2	2.58 7.2
51-60	5 25	Age years Height Cm	51 150	60 176	56.4 161.6	3.38 9.7
21-60 Over all	20 100	Age years Height Cm	21 150	60 170	38.0 164.2	13.8 6.8

2. Hazards Associated with Mobile Crane Operation

2.1. Ergonomic Hazards

Ergonomics (or human factors) is a way to work smarter, more efficiently with less effort and discomfort to the human body. Musculoskeletal disorders occur where the demands of the job exceed the capabilities of the person doing the job Ergonomic hazards may include:

- Physiological factors include the human activities like static sitting, awkward postures, repetitive motions which will develop Musculoskeletal disorders.
- Psychological factors are mental workload, job satisfaction, work stress etc.,
- Social factors like teamwork, participatory system, organizational structures, and cooperative work were considered.

Out these Musculoskeletal disorders are the main complaints among crane operators.

2.2 Musculoskeletal Disorders

"Musculoskeletal Disorders are the result of Poor Ergonomics". Typically, musculoskeletal disorders are not sudden "injuries", but are rather "illnesses" that develop gradually over time. Job-related musculoskeletal disorders are reported frequently above all is low back pain in many working group's causative to a big financial failure to persons and for society too. Trained drivers are prone in emerging such harms due to long time sitting and vibratory exposure. (Aslam et al, 2016)[11]. Along with various types of musculoskeletal disorders, may be, drivers of buses have low back pain which is widely reported in past studies, bus drivers were more prone to lower back pain. Past researches also tells us that male drivers of trucks had four times more prone to lumber disc hernia if compare with deskbound workers group. Many factors are known, those are significant work related stressors and are causative of low back problems and musculoskeletal disorders, other than this, the postural tension and continuous experience of full body vibration are the two most important factors. It is to be considered that the threat becomes more complex, when Manual materials handling is also experienced by the driver along with postural stress and full body vibrations. Call for medical cure and Effect of a variety of uneasiness on occupations daily life were also interrogated, because these components point out severe musculoskeletal injuries. (Szeto GP etal.,-2007)[12]. Subjective discomfort in specific body location was predicted with help of conditional discomfort model through dichotomised physiological responses and anthropometry to predict subjective discomfort in specific body location. (Peter Le et.al, 2014)[13]. Improper design and unbalanced pressure distribution lead to the problem of pain, shoulder pain, lower back pain and injury from lifting increased, overall contour

and proper designing directly and indirectly will have effects on human life (Nishant Srivastava et.al 2014)[14]. Musculoskeletal disorders' do not include musculoskeletal injuries or disorders that are the direct result of a fall, struck by or against, caught in or on, vehicle collision, violence, etc.,

For the crane operator the risk factors for musculoskeletal disorders are:

Crane cabin characteristics and the task characteristics: the interface between the design of the equipment and cab interior (e.g., location of controls, windows, and mirrors) and characteristics of the task (e.g., duration of the task, location of the task that dictates the viewing angle). Thus, the design of the cab interior may influence the possible risk factors of musculoskeletal disorders. Design of interior of a cabin of a truck is importance considering ergonomics, comfort and aesthetics for existing driving conditions in India (Kishor Powar et.al-2009)[15].

Static posture: operators have to sit for long periods of time in the same posture while lifting heavy objects which will lead to the different musculoskeletal disorders. The working postures of the operator can be influenced by many factors, such as workstation layout, location and orientation of work, individual work methods and the workers' anthropometric characteristics (N.K. Kittusamy and et al. 2004)[16].

Work intensity: the amount of physical effort required to perform different tasks like operating controls for lifting the heavy objects or to maintain control of the crane.

High resistance controls: different controls were used in the mobile crane operation namely swinging control, marching control, boom control, hoist control, brake.

Repetitive motions: performing the same motion or series of motions frequent for an extended period of time

Awkward postures: repeated or prolonged positions that place stress on the different parts of the body, such as, bending forward or to the side, twisting, etc., will finally lead to musculoskeletal disorders. The driver's position in the cabin is closely related to the dimensions of the workstation and to the adjustability of the seat, in particular, standard seats have been seen to be unsuitable for both small and heavy drivers (M. Massaccesi et al. -2003)[17].

3. Discomfort Study

Discomfort study was done mainly for assessing location of discomfort, intensity of discomfort and Frequency of discomfort. Location of discomfort can be accessed by a body map, further the operators were asked to indicate the part / parts of the body which was most uncomfortable in order. This procedure was carried out at regular intervals namely, before the starting of work, before mid morning tea, before lunch, before afternoon tea and before the end of work, throughout the day to study the growth of discomfort during their work. Colour coding of the discomfort scores was used for the numerical rating scale (0-4).

0- No discomfort
1- Minimal discomfort
2- Moderate discomfort
3- Severe discomfort
4- Maximal discomfort

Measurement of the intensity of discomfort has usually been attempted by asking the worker to rate the intensity of discomfort for each part of the body at regular intervals on a scale commonly termed a subjective scale. Verbal rating scale is the one in which nouns or adjectives are used to indicate the intensity of the discomfort as no discomfort, minimal, moderate, severe and maximal discomfort. Operators were asked to note or indicate one of the levels of discomfort. Analysis of the obtained data was carried out by the frequency distributions. Numeric rating scale is used to rate the intensity of discomfort in terms of numbers (0-10) where 0 indicates no discomfort and 10 indicates maximal discomfort.

The frequency i.e., how many times the worker is experiencing the discomfort per day/ week was found out to get a correct rating of discomfort of the worker. For this operators' whole working day for a week was considered and the discomfort level of the whole week was taken by interviewing the worker with the help of a questionnaire. Increasing age, work experience, maximum working hours per week, increased left shoulder to handle distance and greater driver seat vibrations are increasing the risk of MSD and restricted lower cabin space reduced shoulder to handle distance on right side also increasing the risk of musculoskeletal disorder(Rahul Shaik et.al.-2012)[18]. 78% of car drivers reported lower back pain for at least one day during past 12 months (Begum Nurun Nahar et.al.)[19]. Professional driving in industry is associated with an increased risk of work-related LBP. (Massinmo Bovenzi et.al2006)[20]. Discomfort Score for a week and Number of operators response for different Age Groups shown in Table-4

4. Results and discussion

While comparing the discomfort level for all the body parts at different time intervals. The discomfort level increases up to afternoon before lunch break, but again goes down after the rest period of one hour where as at the end of the shift the discomfort level is high, in between after morning tea break and evening tea break a little reduction in the discomfort level, a small break in the continuous

operation will have more effect this shows there is a need for short break to reduce the discomfort level (Chart-1).

As per the colour coding body part mapping was carried out to show the intensity of the discomfort level Corlett and Bishop's method of body mapping (1976) [21], is one of the most commonly and widely accepted methods of obtaining information about body pain the same is used for this study Fig. 4,5 and 6.

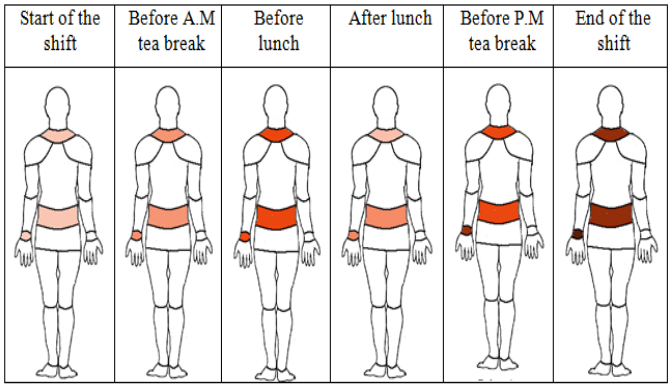

Fig -4: Discomfort mapping Age<40 years

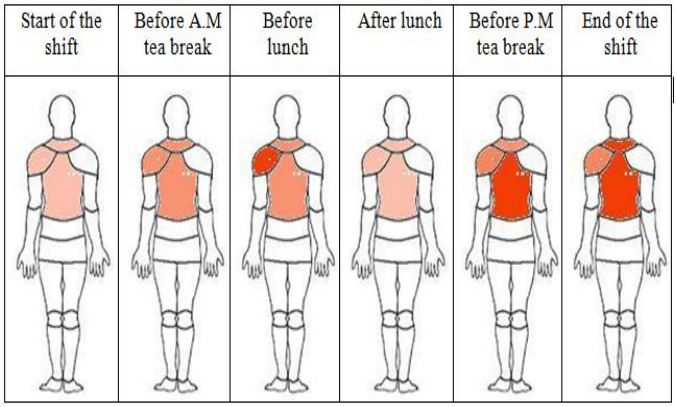

Fig -5: Discomfort mapping Age 41-50 years

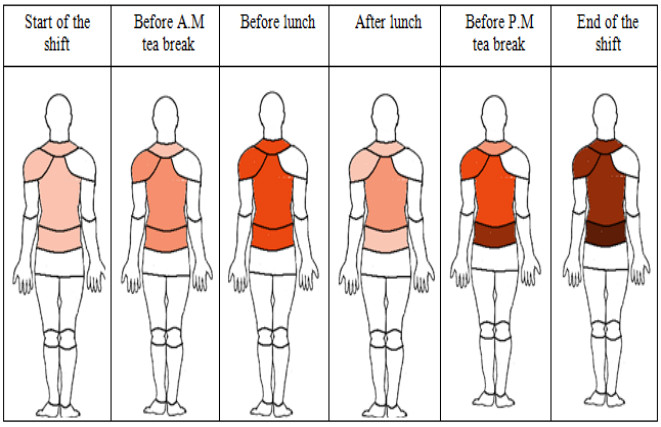

Fig -6: Discomfort mapping Age 51-60 years

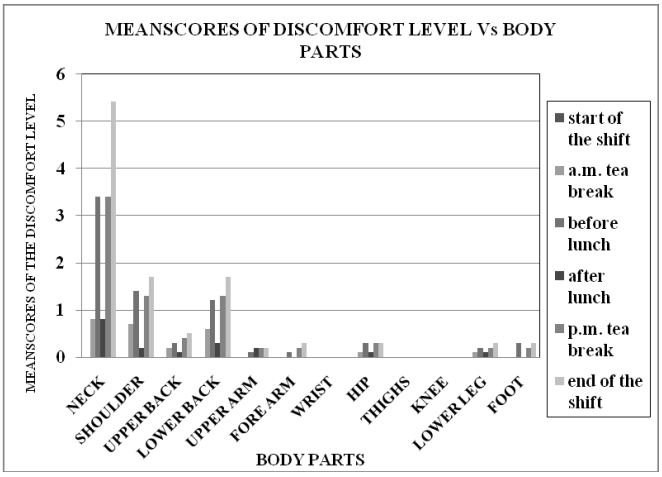

Chart -1: Mean sore of the discomfort level Vs body parts

Table-4: Discomfort Score for different Age Groups

	Frequency of reported discomfort over a week			
Age Group (years)	1 or 2 Times in a week	3 or 4 Times in a week	Every Day	Several times a Day
<40	1.6±0	3.7±0	12±0	46±17.34
41-50	2.6±0.71	7.5±4.80	17.7±8.80	55.3±11.33
51-60	1.9±0.68	9.4±3.30	25.0±6.95	56.2±9.98
Overall	2.3±0.78	7.4±4.72	18.3±8.25	54.0±11.02
No. of operators responding	6(30%)	7(35%)	3(15%)	4(20%)

Specific cab design acceptance level and the discomfort scores are shown in Table 5. For the neck and lower back, the majority of the crane operators scored ≥60%, whereas 4 cranes operators scored for shoulder ≥50%. The crane 6 operators scored less than 50% for all three body parts. Crane 1 and 2, operators scored for neck, lower back and shoulder ≤60 discomfort. The other operators complained mainly about the lower back (static sitting, prolonged working hours) scored 64.29% and suggesting that the cabins have to be improved in all points of view. Though the Crane no.3 in the table is better designed and scored 70.97% acceptance level by all the operators but the discomfort is 60% neck, 50% lower back and 57.14% shoulder respectively which shows the psychological factor also influencing in this.

Table-5: Cabin dimension Acceptance% and body part discomfort level in %

Sl. No.	Make	Cabin dimension Acceptance %	Discomfort level %		
			Neck	Lower back	Shoulder
1	Tata P&H 955 alc	45.16	50	64.29	42.86
2	Tata P&H 320	45.38	60	50	57.14
3	Fmc link belt	70.97	60	50	57.14
4	Rowther Cranes	54.84	60	64.29	57.14
5	Coles krane lh300	58.06	60	64.29	42.86
6	Ace cranes	51.61	40	42.89	42.26
7	Grove cranes	61.29	60	64.29	57.14

5. CONCLUSIONS

It is concluded that the study confirm that the operators of the mobile cranes experience musculoskeletal discomfort at an elevated level at lower back, neck, and shoulders. The results of the discomfort study revealed that irrespective of age group the discomfort level increases up to afternoon before lunch break, but again goes down after the rest period of one hour where as at the end of the shift the discomfort level is high. 20% felt discomfort several times in a day, 15% having every day, 35% of the operators having discomfort 3 or 4 times in a week and 30% experienced one or two times in a week, almost all are expressed that the most affected part is neck, then lower back and then shoulder. Though 70.9% of the operators appreciated the comfortability of a particular make the worst affected part is neck, lower back and shoulder. it provides the information that the mobile crane operation combined with the awkward seating posture, static sitting, uncomfortable features of the cabin is associated with the risk of adverse health effects on neck, lower back and shoulder. The improvement on the crane cabin with space, interior comfort and aesthetics and ergonomically designed seating and controls can reduce discomfort of the operator, occurrence of musculoskeletal disorders, and enhance the overall safety and health of the operators.

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