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Musculoskeletal Discomfort Analysis in Forklift Operations

Kuruva Gopanna[a,d], K. Sankaranarayanasamy[b], A.K. Ganguli[c] and K. Muthukumar[a]

[a]*Safety Management, Bharat Heavy Electricals Ltd., Tiruchirappalli, India*
[d]*Corresponding Author, Email: gopanna@bheltry.co.in*

[b]*Dept. of Mech. Engg., National Institute of Technology, Tiruchirappalli, India*

[c]*National Model Centre for Occupational Health, Bharat Heavy Electricals Ltd., Tiruchirappalli, India*

ABSTRACT:

Although forklifts are well suitable for lifting and moving the goods, there are factors that cause musculoskeletal disorders to the forklift operators, such as severely twisted postures, prolonged sitting and poorly designed workplaces ultimately leading to low productivity. The main objective of this study is to analyze subjective evaluation of musculoskeletal discomfort assessed by the forklift operators using the Cornell musculoskeletal discomfort questionnaire. A total of 47 operators aged between 20-58 years who are driving six types of forklifts in a heavy equipment manufacturing industry were selected for this study. The study revealed that forklift operators felt most of the musculoskeletal discomfort at lower back (65.45%) and in the neck (13.03%). Discomfort was less pronounced in the left upper arm (0.02%) and in the left lower leg (0.03%). Specifically, the results revealed that 40 out of 47 (85.11%) forklift operators sensed discomfort in the lower back 1-2 times per week; 41 out of 47 (87.23%) forklift operators reported discomfort was moderate and above. Because of this, 22 (46.8%) and 16 (34.04%) operators respectively have felt slight and substantial level of discomfort that has an effect on their ability to work.

KEYWORDS:

Musculoskeletal disorders; Cornell musculoskeletal discomfort questionnaire; Discomfort; Forklift operators

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1. Introduction

Productivity is an important indicator of economic growth of an industry. The productivity mainly depends on the operator performance. This can be achieved only when they are comfortable in their workplaces designed for their best performance. Poorly designed work stations, force operator to perform at awkward postures, which leads to Musculoskeletal Disorders (MSD), thereby reducing their efficiency and productivity [1]. There are factors that cause MSD to the forklift operators such as severely twisted postures, prolonged sitting and poorly designed workplaces. The road profile and the condition of the tires also influence the development of MSD to the operators [2]. Among these one of the major factors to develop the MSD is not having a work system design fully incorporating anthropometry based ergonomics [3]. 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 [4].

The operator's workplace, which includes the operator cabin, exposure to noise and the driving posture, needs to be considered as a stress factor contributing to the operational health status. 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 [5]. Poor body posture and inadequate seat support have been described as co-factors in the pathogenesis of MSD of the spine in operators [6]. Therefore, seat comfort has attracted much research focus and continues to receive more support of the automotive industry. 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 [7]. Considering these, forklift operator needs proper seating arrangement to prevent awkward postures during the operation, through this, their problems regarding the MSD can be reduced and at the same time productivity will be increased [8]. This is a preliminary study to investigate the prevalence of MSD problems among the forklift operators operating six types of forklifts in heavy equipment manufacturing industry. The result of this study will be used to further investigate the effect of the MSD on the operator's productivity.

2. Materials and methods

2.1. Operators data

A study was conducted among the forklift operators in a heavy equipment manufacturing industry. Total 47 forklift operators (100% of all male operators) in the age group between 20-58 years participated in this study. The minimum and maximum height of the operator was 158 cm and 185 cm respectively. The minimum and

maximum weight was 50 kg and 90 kg respectively. The minimum and maximum number of years of experience in operating the forklift was 0.5 years and 30 years respectively. All operators were provided with the information about the study and consent was obtained from all operators prior to their participation in the study. None of the operators involved reported with health issues that are likely to affect or to be affected by participation in this study.

2.2. Forklift survey

In this survey about 47 forklifts consisting types of 4 diesel operated from makes of Voltas, Godrej, Ace and Doosan respectively and 2 electrically operated from makes of Voltas and Macneill (designated as D1, D2, D3, D4, E1 and E2 respectively) are operated by the company employees and contractors. All forklifts are of 3 tons capacity. In this industry, forklifts are used to lift and transport small jobs like metal plates weighing 30kg to heavy jobs like valve bodies weighing 3 tons. These materials are transported within the shop floor or to other workshops and even materials shipped for a distance of 1.5 km. While transporting heavy jobs like valve body packing, forklifts have to be driven in reverse direction because the jobs will block the front vision of the operator. Therefore, in such situations, operators must twist their trunk to get visibility. It is interesting to know that, most of the forklifts were not provided with seat height (vertical) adjustment mechanism. The forklifts were studied to record the seat height. Because seats are one of the most important components for forklifts and they are the place where forklift operators spend most of their time. The forklift seat height was compared to the anthropometrically recommended values of 5th percentile popliteal height [9].

2.3. Discomfort assessment

Discomfort assessment was carried out using the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ). The CMDQ is a 54-item questionnaire containing a body map diagram and questions about the prevalence of musculoskeletal ache, pain or discomfort in 20 regions of the body during the previous week. It has been used in the assessment of musculoskeletal discomfort among different working populations, such as nursing personnel [10] and Computerized Numeric Control machine operators [11]. To determine the frequency of discomfort and quantify the discomfort level, the musculoskeletal discomfort score was calculated as per the CMDQ scoring guidelines. The musculoskeletal discomfort score was calculated as follows. First, the frequency of discomfort reported by the operators during the survey was scored as: Never (0), 1 or 2 times/week (1.5), 3 or 4 times/week (3.5), every day (5), or several times every day (10). The score obtained is then multiplied by the severity score (slightly uncomfortable = 1, moderately uncomfortable = 2, very uncomfortable = 3) and interference score (Not at all = 1, slightly interfered = 2, substantially interfered = 3) to arrive at the weighted musculoskeletal discomfort score. This helped to identify the most severe cases.

3. Results and discussions

3.1. Forklift survey

The survey results of 47 forklifts as given in Table 1 indicated that the actual seat heights of six different types of forklifts are widely varied from the anthropometrically recommended value (40 cm) for the 5th percentile [12]. The differences of actual values from the recommended value range from 3.1 cm in D3 to 13.8 cm in E1. It is recommended that the seat height from the floor to the front edge of the cushion should not exceed the popliteal height (40 cm) of small men. It is concluded that, the seat height of all six types of forklifts were not as per the recommendations.

Table 1: Comparison of forklift seat height with recommended values (5th percentile popliteal height)

Forklift (Make)	Quantity	Seat height (in cm)		
		Actual	Recommended	Difference
D1	19	46.5	40.0	6.5
D2	7	48.2	40.0	8.2
D3	2	43.1	40.0	3.0
D4	7	44.5	40.0	4.5
E1	5	53.8	40.0	14
E2	7	48.1	40.0	3.0

3.2. Discomfort assessment

In this study face to face interview was conducted to obtain the discomfort information from the forklift operators and their operations were also observed directly in their course of work. Normal working shift hours for the forklift operation was from 8 to 16.30 hours and in-between there are three breaks such as morning break (10 minutes), lunch break (30 minutes) and afternoon break (10 minutes). Most operators are operating the forklift from 5 to 6 hours a day. The questionnaire results are shown in Table 2 and Table 3. According to Table 2, more specifically the results revealed that, in the lower back, 14.89% of the forklift operators reported discomfort 1 to 2 times in a week, 27.66% experienced discomfort 3 to 4 times in a week, 23.4% reported the discomfort daily and 25.53% had discomfort several times a day. Further results revealed that, 41 out of 47 (87.23%) forklift operators expressed that, discomfort level was moderate and above in the lower back, because of this, 22 operators assessed that, this discomfort has slightly interfered with their ability to work and 16 out of 47 forklift operators assessed that substantially have an effect on their ability to work.

Similarly, in the neck, 8.51% of the forklift operators reported discomfort 1 to 2 times in a week, 25.53% experienced discomfort 3 to 4 times in a week, 17.02% reported the discomfort daily and 8.51% had discomfort several times a day. 32 out of 47 (68.09%) forklift operators sensed discomfort was moderate and above in the neck, because of this 15 out of 47 and 9 out of 47 forklift operators were assessed that, this discomfort slightly and substantially had an effect on their ability to work respectively. According to Table 3, forklift operators felt most of the musculoskeletal discomfort in the lower back (65.45%) and in the neck (13.03%), while the discomfort is the least pronounced

in the left upper arm (0.02%) and in the left lower leg (0.03%). The study suggests that, the causative factors may be the seat heights widely vary from the anthropometrically recommended value and the frequent twisting of the neck during the transporting the heavy jobs in reverse direction. The study suggested that, the seat height from the floor, measured at the highest surface of the cushion, should not exceed 40cm to accommodate up to 99% of the Indian male population and seat height adjustment along with a horizontal adjustment mechanism may be incorporated to set the seat for their comfort. Secondly, big rear view mirrors to be fixed in the forklifts at suitable location. These rear view mirrors make it possible for the operator to adopt a good working posture while operating the forklift in reverse direction.

Table 2: Subjects' variations of estimating the feeling of discomfort by using CMDQ

Body Part	During last work week how often did you experience ache, pain, discomfort in:					If you experienced ache, pain, discomfort, how uncomfortable was this?			If you experienced ache, pain, discomfort, did this interfere with your ability to work?		
	Never	1-2 times last week	3-4 times last week	Once every day	Several times every day	Slightly un-comfortable	Moderately un-comfortable	Very un-comfortable	Not at all	Slightly interfered	Substantially interfered
Neck	19	4	12	8	4	6	16	6	4	15	9
Shoulder-R	31	5	7	3	1	6	8	2	7	6	3
Shoulder-L	29	9	6	3	0	8	8	2	9	6	3
Upper arm-R	41	1	3	2	0	0	6	0	2	4	0
Upper arm-L	43	1	2	1	0	0	4	0	2	2	0
Upper back	40	5	1	1	0	2	5	0	2	4	1
Lower back	4	7	13	11	12	2	27	14	5	22	16
Forearm-R	38	9	0	0	0	8	1	0	8	1	0
Forearm-L	38	9	0	0	0	8	1	0	8	1	0
Hip	24	6	9	3	5	10	12	1	10	11	2
Knee-R	25	7	6	3	6	3	17	2	6	14	2
Knee-L	28	8	4	2	5	9	8	2	11	5	3
Lower leg-R	41	1	3	2	0	0	6	0	0	6	0
Lower leg-L	43	1	2	1	0	0	4	0	0	4	0
Foot-R	28	7	6	3	3	5	12	2	8	9	2
Foot-L	34	4	5	1	3	4	8	1	6	6	1
Wrist-R	31	7	6	2	1	7	7	2	8	5	3
Wrist-L	29	7	7	4	0	8	8	2	9	6	3
Thigh-R	39	5	2	0	1	4	2	2	5	2	1
Thigh-L	39	5	1	1	1	5	2	1	5	2	1

Table 3: Total discomfort felt by the forklift operators

Body parts referred in the questionnaire	Frequency of discomfort	Intensity of discomfort	Interference	Total discomfort score	%
Lower back	231	98	97	2195886	65.45
Neck	128	56	61	437248	13.03
Knee-R	106.5	43	40	183180	5.46
Hip	105.5	37	38	148333	4.42
Foot-R	76.5	35	32	85680	2.55
Knee-L	86	31	30	79980	2.38
Wrist-L	55	30	30	49500	1.48
Shoulder-R	57	28	28	44688	1.33
Shoulder-L	49.5	30	30	44550	1.33
Wrist-R	51.5	27	27	37543.5	1.12
Foot-L	58.5	23	21	28255.5	0.84
Thigh-R	24.5	14	12	4116	0.12
Thigh-L	26	12	12	3744	0.11
Lower leg-R	22	12	12	3168	0.09
Upper arm-R	22	12	10	2640	0.08
Upper back	16	12	13	2496	0.07
Forearm-R	13.5	10	10	1350	0.04
Forearm-L	13.5	10	10	1350	0.04
Lower leg-L	13.5	8	8	864	0.03
Upper arm-L	13.5	8	6	648	0.02

4. Conclusions

The study indicated that the feeling of discomfort, subjectively felt by forklift operators was higher in the lower back and neck. Further research is needed on the relationship between musculoskeletal discomfort and productivity. Hence the result of this study will be used to further investigate the effect of the MSD on productivity.

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GUEST EDITORS: Dr. T. Ramesh and Dr. N. Siva Shanmugam, Department of Mechanical Engineering, National Institute of Technology, Tiruchirappalli, Tamil Nadu, India.