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Ergonomic Evaluation of Work Related Musculoskeletal Disorders and Postural Stress among Bell Metal Workers of West Bengal, India

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ABSTRACT

Bell metal handicraft manufacturing is one of the oldest cottage industries in India. The workers had to adopted different awkward postures while performing different bell metal jobs. The purpose of the current study was to evaluate the prevalence of musculoskeletal disorders and identify ergonomic risk factors related to pain in the bell metal workers. A cross-sectional study was conducted among 370 male bell metal workers in rural small scale industries of Bankura and Purulia district, West Bengal, India. Modified Nordic Questionnaire Method and Body Part Discomfort scale were applied to identify MSDs in different body parts. The postural pattern was assessed by direct observation method. The postural stress was analyzed by OWAS, REBA and RULA methods. The results showed that the prevalence of MSDs was very high among the workers and the most affected areas were back and upper extremity. The workers performing smelting and hammering/scraping activities had a significantly higher prevalence of MSD in the different body segments than that of paddle roller. The prevalence of MSDs exhibited variation in the participants having different work experience. Squatting postures was the dominating postures in bell metal jobs. Postural analysis indicated that the workers had to adopt different stressful postures during performing different bell metal jobs. During smelting and hammering/scraping operation the workers were subjected to greater postural stress than that of paddle rolling. Postural stress might be the reason for the occurrence of MSDs. Thus, immediate ergonomic interventions are needed to reduce work stress of the workers by correcting awkward postures.

Key wards: *Bell metal worker, MSDs, Work experience, Postural stress.*

INTRODUCTION

Musculoskeletal Disorders (MSDs) is the catch-all term used to describe all work-related injuries and disorders of the back, upper and lower limbs that result in pain and impairment problems for workers. The phenomenon has been variously branded as the 'workplace epidemic' or even the 'occupational plague of the future' in a bid to spotlight the extent of this major and growing occupational problem in industrialised countries[1].

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According to data from the Workers Compensation Board of India, there was a high rate of musculoskeletal injuries was seen in the unorganized industry in India.

The burden of musculoskeletal disorders is global and looking at the gravity of the situation WHO declared 2000-2010 as the Bone and Joint decade. Risk factors include physical, psychological, and socio-demographic aspects[2]. Physical ergonomic factors such as the combination of load and postures, repetitive bending of the wrist, vibration and localized mechanical pressure[3], prolonged periods of improper squatting, standing or walking trunk twisting4, monotonous work are associated with MSDs[5].

Psychological demands and social work factors for MSDs include job demands and social or co-worker support job satisfaction[6], a degree of satisfaction with leisure time activities, high job insecurity and work stress[7].

Bell metal handicraft manufacturing, which is usually done at home in small-scale industries, is one of the oldest cottage industries in Nepal, China, Japan, Korea, Thailand, Pakistan and in India, particularly in West Bengal (SISI report, Buttack cluster Balakati: 2005-2006). In this job household utensils are prepared in a large scale. Bell metal is an alloy (78:22) of copper (Cu) and Tin (Sn). At an above 1084°C[30], Cu and Sn are melted in a ceramic furnace by using coal to prepare a bell ingot. A hot ingot is continuously beat with heavy weighted hammerer for giving shape and then utensils are scraped and designed by engraving with cutters. Finally they are polished by rolling paddle by paddle roller with back ward bending posture and made ready for sale. Continuous heating-cooling and hammering in squat with forward bending and side bending postures are the most predominant activity in the entire work process. This work task often involves bell metal workers being ergonomically awkward activities, such as the repetitive bending, twisting and hammering movement which are often repeated two hundred times per day in awkward postures of the upper limbs, lower limbs neck, trunk, and legs. These ergonomic problems may be a cause of MSDs in bell metal manufacturing workers. However, our literature review shows that the ergonomic risk assessment of bell metal work and the association with MSDs has never been evaluated. To effectively address MSDs problems and postural stress among bell metal workers, this study aimed to evaluate the prevalence of musculoskeletal disorders and ergonomic risk levels of working postures, and also identify ergonomic factors influencing MSDs among bell metal workers.

MATERIALS AND METHODS

Study population and sample size

A cross-sectional study was conducted on the bell metal workers in Bankura and Purulia and Midnapur (W) District, West Bengal province who were employed in a bell metal work station at least four years. These two districts were specifically chosen because bell metal works are predominantly carried out in these districts and are done by only male workers. The study was carried out on 370 male bell metal workers having the age between 20 and 60 years old. Out of the existing 370 workers, 303 workers were chosen for the study and rest were excluded from the study. Participants who had any history of major back trauma such as a motor vehicle accident, sports injury, fall from height, potentially serious spinal condition including compression fracture, spinal infection, ankylosing spondylitis, spinal stenosis, herniated disc, drug abuse and mental disorder were excluded. This study was approved by the Institutional Ethics Committee and the study was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration. Prior to the study, the protocol was explained verbally in local language (Bengali) and signed consents were obtained from the study participants. The entire study was conducted in the year November, 2014 to March, 2016.

Physical Parameters:

Anthropometric measures were taken from the subjects following standard technique and appropriate landmarks[8]. Height was measured to the nearest 0.1 cm using anthropometer (Hindustan Minerals, The Hindustan Mineral Products Co. Ltd., Kolkata, India) and weight to the nearest 0.1 kg using a portable weighing machine (Libra, Libra Weighing Machine Limited, Bangkok, Thailand). From measures of height and weight of the subjects, the body mass index (BMI) was computed using the following standard equation: BMI = weight (kg)/height (m^2) [9].

Musculoskeletal disorder:

The musculoskeletal disorders of the workers were evaluated by the modified Nordic Questionnaire technique[10]. The questionnaire emphasized their individual details, type of work and the occurrence or frequency of pain felt in different parts of their body.

Discomfort Rating:

The intensity of pain or different types of discomfort of the bell metal workers was evaluated by utilizing the body part discomfort (BPD) scale[11]. The scale consisted of marks from 1 to 10 and ranges from just noticeable discomfort to intolerable discomfort. A '0' in the scale meant no discomfort at all and '10' in the scale indicated intolerable discomfort. The mean value of scores (perceived rating of discomfort) of all segments was taken as the overall discomfort rating of the workers. According to the degree of severity, the scores of the 10-point scale were divided into three subgroups, i.e., mild (1 – 4), moderate (>4 – 7) and severe or intolerable pain (>7)[12].

Work-Rest Pattern:

The work rest patterns of bell metal workers was determined by directly observing their different types of work as well as by taking interview of the workers[13]. The work rest cycle of different tasks of workers was studied by noting the actual work time and rest time. The total work shift was divided into work cycle and rest cycle. The rest period is the sum of prescribed rest pause (rest for food break) and job related rest pause (rest taken by the worker for self requirement during working hour). The actual work time was calculated by subtracting the actual rest pause from total work time. It was recorded carefully from beginning to end of the work by direct observation employing video-photography of the work. For this purpose, whole day works of the workers were recorded by a video recorder (SONY DCLR-SR88) and analyzed by using the software Xing MPEG player (Version 3.30). After a careful and repeated observation, the whole day work of the workers was evaluated and the duration of work time and different rest pauses of the workers were noted.

Postural Pattern:

For evaluating the postural stresses, the postural pattern of the workers during performing their jobs was studied. The analysis of posture in different phases of bell metal tasks was made by the direct observation method employing video-photography[13]. The work posture of each subject was studied for each type of job for a whole working period. The postural change during performing the work was noted carefully and the time for adopting each posture was recorded. The observation was made by employing one subject one day strategy.

Assessment of Work Posture:

The postures adopted by the bell metal workers in their working place depends upon the type of work, personal characteristics, the tools required to perform the particular work and also the duration and frequency of the work cycle. Postural analysis can be a powerful technique for assessing work activities as the risk of musculoskeletal injury associated with the posture [14]. So, various techniques have been applied for postural analyses to identify the stress of different phases of work.

Working postures were evaluated by using OWAS (Ovako Working postures Analysis System) method[15]. Although the OWAS method has a wide range of use, but the results can be low in detail. Therefore, the

Rapid Entire Body Assessment (REBA) method[16]and Rapid Upper Limb Assessment (RULA) method[17] was also applied for analysis work posture of the workers. Researchers used several posture analysis methods viz. OWAS, RULA, REBA etc. simultaneously for posture analysis. This was the reason for applying four methods for posture analysis.

Statistical analysis:

Age, anthropometric measures and work experience were described by their means and standard deviations. To test the significance of difference between the parameters, the students't-test was performed. Chi-square analysis was done to determine the differences in the prevalence of MSDs among different work categories. A software SPSS version 20 was used for all analyses, and statistical significance was set at <0.05.

RESULTS

Table 1: The demographic characteristics of the Bell metal workers (n= 303).

Variables	Mean±SD	Range
Age (years)	41.14±11.77	18-60
Height (cm)	162.19±4.161	146.4-173
Weight (kg)	52.52±4.75	42-70
BMI (kg/m^2)	19.95±1.35	17.1-27.1
Working days/week	6.2±0.73	4-7
Work Experience (years)	25.12±11.76	4-48

Table 1 indicates the demographic characteristics of the Bell metal workers. Nutritional status of the workers was assessed from their BMI values (WHO, 1995) [18]. Most of the participants had BMI in normal value (19.95±1.35) and it was revealed that about 85.8% of the participants had 'normal' weight (BMI 18.5 to 24.9 kg/m^2). The prevalence of underweight was 18.4% among the workers, while a low percentage (1.98%) of them were classified as overweight. The workers had an average working experience of more than 25 years.

The prevalence of musculoskeletal disorders (MSD) of the bell metal workers was evaluated using the modified Nordic Questionnaire method and the occurrence of MSDs was presented in Table 2.The results revealed that the occurrence of MSDs was significantly different in different sites of the body parts between the workers engaged in bell metal manufacturing process. The most prevalent MSD was noted in the lower back (88.61%), followed by the wrist (83.85%) and shoulder (77.78%) when all tasks were considered together. These were followed by problems of MSD in the knee (73.91%), neck (68.94%), thigh (63.49%) and upper back (54.66%).

The workers performing smelting and Hammering/scraping activities had a significantly higher prevalence of MSD in the lower back ($p<0.001$) and neck ($p<0.001$) than that of paddle rolling operator. Smelters had significantly higher percentage of MSDs in shoulder ($p<0.001$), wrist and thigh ($p<0.05$) than that of the paddle rolling operator. In addition, it was also observed that hammerer/scraper had higher percentage of MSDS in shoulder ($p<0.01$), wrist ($p<0.001$) and thigh ($p<0.01$) than that of paddle rolling operator. There was a significant difference in the occurrence of pain / discomfort in neck ($p<0.001$), shoulder ($p<0.01$), wrist ($p<0.01$), lower back ($p<0.001$) and thigh ($p<0.01$) among the workers.

Table 2: Comparison of frequency and (percentage) of the occurrence of MSDs among smelters, hammerers/scrapers and paddle rolling operators of Bell metal workers.

Body segments	Categories of Bell metal workers			χ^2
	Smelter (n=79)	Hammerer/Scraper (n=161)	Paddle roller (n= 63)	
Neck	53 (67.09)***	111 (68.94)***	22(34.92)	23.58 †††
Shoulder	91 (56.52)***	49 (77.78)**	40(50.63)	11.894††
Elbow	28(35.44)	52 (32.30)	19 (30.16)	0.467
Wrist	62(78.48)*	135 (83.85)***	39 (61.90)	12.685 ††
Upper back	40(50.63)	88 (54.66)	31 (49.21)	0.685
Lower Back	70(88.61)***	135 (83.85)***	37 (58.73)	22.848 †††
Thigh	33(41.77)*	64 (39.75)**	40 (63.49)	10.814††
Knee	50(63.29)	119 (73.91)	44 (69.14)	2.871
Feet	11(13.92)	25 (15.53)	15 (23.81)	2.864

w.r.t. (with respect to) Paddle Roller *p<0.05, **p<0.01, ***p<0.001

†† p<0.01, †††p<0.001

Complete information about the work experience of the bell metal workers was noted on a questionnaire basis and the workers were divided into three groups: Gr.-A (work experience ≤15 years); Gr.-B (work experience 16-31 years) and Gr.-C (work experience ≥31 years). It was observed that about 26.73% workers had work experience of ≤15 years, 37.95% and 35.31% of workers had an experience of 16-30 years and ≥31 years respectively.

The occurrence of MSDs in different work experience groups has been presented in Table 3. Gr.-A had significantly higher percentage of MSDs in the shoulder (82.72%) and thigh 74.07% than that of Gr.-C and Gr.-C. The workers of Gr.-B had significantly higher percentage of MSDs in neck (66.96%), wrist (82.61%), upper back (58.26%) and lower back (86.96%) than that of Gr.-A workers. The higher occurrence of MSDs in different body parts was found in the most experience workers, (Gr.-C). This group of workers had significantly higher prevalence of pain/discomfort in the lower back (91.59%), neck (79.44%) and wrist (85.05%) compare to the Gr.-A workers. They also had significantly higher prevalence of pain/discomfort in neck region compare to the Gr.-B workers.

Table 3: Prevalence of MSD in Bell metal workers on the basis of their work experiences ('f ' indicates frequency, Gr. indicates Group and the values in parenthesis indicate the percentage of respondents).

Body segments	Gr.-A (≤15 yrs) (N= 81) f (%)	Gr.-B (16-30 yrs) (N= 115) f (%)	Gr.-C (≥31 yrs) (N= 107) f (%)	χ^2
Neck	24 (29.63)	77 (66.96)***	85 (79.44)***#	50.679 †††
Shoulder	67 (82.72)	79 (68.70)*	34 (31.78)***##	56.24 †††
Elbow	25 (30.86)	34 (29.57)	40 (37.38)	1.705
Wrist	50 (61.73)	95 (82.61)**	91 (85.05)***	16.953 †††
Upper Beck	33 (54.32)	67 (58.26)*	59 (55.14)	6.321 †
Lower back	44 (54.32)	100 (86.96)***	98 (91.59)***	45.614†††
Thigh	60 (74.07)	52 (45.22)***	25 (23.36)***##	47.857 †††
Knee	53 (65.43)	77 (66.96)	83 (77.57)	4.243
Feet	22 (27.16)	20 (17.39)	9 (8.41)***#	11.618 ††

w.r.t. Gr.-A*p<0.05, **p<0.01, ***p<0.001;

w.r.t. Gr.-B #p<0.05, ##p<0.01, ###<0.001; † p<0.05, †† p<0.01, †††p<0.001

Table 4: The perceived rate of discomfort (Mean±SD) in different body segments of the bell metal workers during performing different types of task (in a 10 point scale)

Body segments		Categories of Bell metal workers		
		Smelter (n=79)	Hammerer/ Scraper (n=161)	Paddle roller (n=63)
Neck		4.80±2.27	4.93±2.03	2.59±2.64$^{***\#\#\#}$
Shoulder	Left	3.77±2.36	4.25±2.01	3.28±1.92$^{\#\#\#}$
	Right	3.68±2.33	4.13±2.02	3.21±1.88$^{\#\#}$
Upper-arm	Left	3.18±1.85	3.19±2.12	2.63±1.8$^{\#}$
	Right	3.22±2.09	3.11±2.04	2.56±1.66*$^{\#}$
Lower-arm	Left	4.49±1.19	4.98±2.16*	3.16±2.01***$^{\#\#\#}$
	Right	4.89±2.28	4.29±2.11*	3.14±2.26***$^{\#\#\#}$
Upper-Back		3.01±2.56	1.99±2.15**	1.41±1.58***$^{\#}$
Mid-back		1.09±2.01	0.9±1.67	0.87±1.49
Lower-Back		7.21±3.77	7.45±2.1	4.6±2.36$^{**\#}$
Buttock		0.78±1.32	0.96±1.58	0.86±1.65
Thigh	Left	2.56±2.3	2.4±2.20	3.59±2.44$^{*\#\#\#}$
	Right	2.43±2.24	2.21±2.25	3.54±2.53$^{**\#\#\#}$
Leg	Left	2.35±2.32	2.68±2.48	2.92±2.44
	Right	2.35 ±2.38	2.01±2.01	2.63±2.13#
Ankle	Left	2.57±2.34	2.44±2.06	2.22±2
	Right	2.05±2.22	1.85±1.82	2.1±2.13
Overall BDP of the body		3.09±0.86	3.17±0.81	2.66±0.73**$^{\#\#\#}$

w.r.t. Smelter $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

w.r.t. Hammerer/Scraper $^{\#}p<0.05$, $^{\#\#}p<0.01$, $^{\#\#\#}p<0.001$

The quantitative assessment of the pain/discomfort of the bell metal workers engaged in different tasks have been presented in Table 4. The perceived rating of discomfort of the workers was assessed by using a 10-point scale which was graded from Grade 0 (no pain) to Grade 10 (very severe pain). The results showed that the different type bell metal workers reported different degrees of perceived exertion indifferent body segments. It was revealed that there was a moderate degree of pain/discomfort (>4 to 7) in lower back among smelter, hammerer/scraper and paddle rolling operators. It was revealed that smelter had a significantly higher ($p<0.05$ or less) degree of pain/discomfort at upper back and lower arm than that of hammerer/scraper and paddle rolling operators except left lower arm of hammerer/scraper. Hammerer/scraper and smelter perceived significantly higher degree ($p<0.05$ or less) pain/discomfort in neck, upper arm, lower arm, upper back and lower back than that of paddle rolling operators. Hammerer/scraper had significantly higher ($p<0.05$ or less) degree of degree pain/discomfort in shoulder ($p<0.01$) than that of paddle rolling operators. However, there was a significantly higher ($p<0.05$) degree perceived pain/discomfort in thigh segments of paddle rolling operators than that of smelter and hammerer/scraper.

Table 5: Mean±SD and percentage (%) of time (minutes) for adopting different postures in a work shift of Bell metal worker during performing different jobs

Different working posture	Different types of Bell metal worker		
	Smelter (n=79)	Hammerer/Scraper (n=161)	Paddle roller (n=63)
Standing with forward bending	72.48±8.73 (18.31%)	37.66±10.39*** (9.54%)	32.68±11.48***# (9.84%)
Squatting with forward bending	184.46±22.59 (46.59%)	221.89±25.71*** (56.21%)	-
Squatting with twisting	138.95±9.35 (35.1%)	135.20±13.13* (34.25%)	-
Sitting with back bending	-	-	299.3±39.17 (90.16%)
Total working period	395.89±24.39 (100%)	394.75±21.6 (100%)	331.98±30.72 (100%)

w.r.t. Smelter *p<0.05, **p<0.01, ***p<0.001

w.r.t. Hammerer/Scraper #p<0.001

The direct observation method was followed to analyse of postural patterns (Table 5) of the bell metal workers. Continuous heating-cooling and hammering of the bell metal ingot in squatting posture was the most predominant activity in the entire work process. The smelters were found to squatting with twisting frequently during ingot heating and replica modeling process. They had also to adopt standing with forward bending and squatting posture for 18.31% and 81.69% respectively of the total work-time. Hammerers/scrapers had to adopt 56.21% squatting with forward bending, 34.25% squatting with twisting and 9.54% standing with forward bending during their work time respectively. Continuous sitting with back bending posture was the most predominant activity of paddle roller and they had to adopt this posture 91.16% of their total wok time.

Table 6: Percentage (%) distribution of bell metal workers in action different categories followed by OWAS, RULA and REBA postural analysis methods

Methods	OWAS					RULA					REBA					
Action categories score (%)	1	2	3	4	Dominant action category	1 to 2	3 to 4	5 to 6	7	Dominant action category	1	2 to 3	4 to 7	8 to 10	≥ 11	Dominant action category
Smelter	-	2.53	59.49	37.97	3	-	-	5.06	94.94	7	-	-	-	8.86	91.14	≥11
Hammerer /scraper	-	27.33	57.76	14.91	3	-	-	27.33	72.67	7	-	-	-	24.84	75.16	≥11
Paddle rolling operators	26.98	69.84	3.17	-	2	1.00	98.41	1.59	-	3 to 4	-	95.24	3.17	1.59	-	2 to 3

The results of the posture analysis by employing OWAS, RULA and REBA methods have been presented in Table 6. It has already been mentioned that the dominant posture adopted by the smelter was squat sitting posture. From the results of postural assessment by OWAS method, it was found that the posture needed corrective measure as soon as possible. Similarly, from the results of postural assessment by RULA and REBA methods, the squat sitting postures was categorized as very high risk and it needed immediate change.

In case of paddle rolling operators, the results of postural assessment by OWAS method indicated that the posture needed corrective measures in near future. Similarly from the results of postural assessment by RULA and REBA methods, it was found that the posture adopted during paddle rolling task was of low risk and may be needed change of the posture.

DISSCUSSION

Different occupational epidemiologic findings have shown strong and consistent association between musculoskeletal disorders (MSDs) and several occupational exposures such as forceful exertions, highly repetitive motions, sustained static muscle loading, lack of sufficient rest, awkward body postures, localize mechanical stress, whole body and segmental vibration, high and low temperature and features of the organisational structure of the working environment such as restrictive, high demand low control-jobs[19]. The current study investigated the potential ergonomics hazards of three types of manual tasks (smelting, hammering/scraping and paddle rolling) of bell metal workers.

The work-rest cycle was dichotomized process which is an integral part of the operation of periods muscles and heart and if we take all the biological functions into account of the organism as a whole. Work rest is, therefore, indispensable as a physiological requirement if performance and efficiency are to be maintained. From the studies of work-rest patterns of the bell metal worker, it has been found that total duration of work shift was high (more than 8 hours) which was continued 6 days per week. Thus the prolonged tasks performed in awkward posture may be feasible causes of pain at different segments of the workers. It was also point out that prolonged tasks have been positively associated with body part discomfort[20]. In addition, those performing highly repetitive tasks for longer duration reported pain at different segments of their body[21].

Low back and wrist pain were found extremely prevalent in all types of tasks performed by the bell metal workers. Low back pain was highest in smelter (88.61%), followed by hammerer/scraper (83.85%) and paddle rolling operators (58.73%). This problem might be attributed to the prolonged squat sitting with forward bending and twisting posture especially in combination with the use of heavy weight hammering, scraping and smelting tasks performed by the bell metal workers. The kneeling, squatting and non-neutral trunk postures were responsible for lower back disorder[22]. It was reported that repetitive trunk motion affected the pattern of trunk muscle coactivity that appeared to be the driving force behind diminished strength and functional capability as well as increased spine structural loading that include both compression and shear force[23].

Moreover, the high frequency of heavy weight hammering was a co-factor affecting low back pain for bell metal worker which might be due to increased intradiscal pressure (IDP) that can include annular tears and internal disk disruption resulting in lumber disc injury[24].

Wrist pain was highly prevalent (hammerer/scraper: 83.85%; smelter: 78.48%; paddle roller: 61.90%) among the bell metal worker. The repetitive prolonged hand intensive activities, degree of flexion of wrists, forceful exertions awkward or static posture, repetitive bending of the wrist, vibration, temperature extremes and localized mechanical stress were the common in the smelting and hammering tasks which might be

the possible factors for the occurrence of wrist problems[19]. The results also indicated that MSDs was prevalent in shoulder of the bell metal worker. Disorder in the shoulder was highest in hammering/scraping job (77.78%) than that of smelting task (56.52%) and paddle rolling job (50.63%). However, the frequency of repetitive movement of shoulder, arm, hand and legs was very higher in case of hammering/scraping task for giving a shape of the product in comparison to other two tasks. Further, during hammering/scraping the workers needed to bend forward for a long time as well as to lift a hammer having the weight of 3 to 3.5 kg frequently from the level of work surface to the above shoulder level as result of shoulder was abduct, disabling injuries of the soft tissues, usually of the hands, wrists, forearms, shoulders, back and legs This might be the possible for the occurrence of shoulder pain of the workers during hammering/scraping.

Neck pain was also prevalent in all types of tasks performed by the bell metal workers. This problem might be attributed to the prolonged forward bending and twisting of the neck in addition with trunk twisting[25]. The highest prevalence of thigh discomfort (63.49%) was found paddle rolling operators than that of smelters (41.77%) and hammerers/scrapers (39.75%). Actually, the bell workers were needed to roll the paddle continuously for polishing bell utensils by the legs. Continuous pressure load was acted on thighs with repetitive motion which compressed the thigh muscle and sciatic nerve and that might be the causes of pain/discomfort in the thigh[25].

In the present study an association was found between years of experience with the prevalence of musculoskeletal pain in bell metal workers. The workers who had worked more than 5 years had an increased prevalence of MSDs. In a previous study, reported an association between musculoskeletal pain and years of experience in the construction industry[26]. They noted that the prevalence of musculoskeletal pain was 33% in workers who work less than 5 years in the industry and it was increased to 40% when working years were 6–10 years. The prevalence further increases to 84% when the working years increased to 30 years.

In the present study, the occurrence of perceived rate of discomfort in neck, upper back, lower back and left ankle was higher in the subjects with experience of more than 31 years (Gr.-C) and 16-30 years (Gr.-B) than that of subjects having work experience of less than ≤15 years (Gr.-A). The higher incidence of BPD in the workers of Gr.-C might be due to reduced muscle strength and endurance with the advancement of age [25]. On the contrary, occurrence of BPD in shoulder, thigh and leg was lesser with more experienced workers especially in Gr.-B, and Gr.-C. It was reported that long term professional experience may help them desensitize more specifically against the pain of others. Thus it may also decrease the positive aspects of professional quality of life[26].

The bell metal workers were compelled to adopt in different awkward squat postures for prolonged period while performing different bell metal manufacturing tasks. Ergonomic assessment of work postures is one of the starting points to address the problem of work related body segment pain. In the present study, different work postures were analyzed by OWAS, RULA and REBA methods. From the results of posture analysis of three jobs of the bell metal work, it was revealed that the dominant action category of OWAS method was 3, RULA for 7 and REBA for ≥11 in both smelter and hammerer/scraper. These postures were of very high risk and it needed immediate change. On the other hand, dominant action categories were 2 for OWAS, 3 to 4 RULA and 2 to 3 for REBA for the paddle rolling operators that means, their postures were of low risk, although change may be needed. Studies of MSDs and discomfort rating revealed that the workers performing different bell metal tasks were reported to have pain/ discomforted in different body segments which might due to their postural pattern as well as duration of work in awkward postures. Several researchers

reported that the major work-related risk factors associated with lower back pain have been identified as results of adopting awkward work postures[27]. Awkward working posture usually occurred when the workers performed the job with their body parts deviating significantly from the natural posture. When performing job in such working posture, high force was applied in the skeletal system which might lead to acute overloading and damage of skeletal structures. It was reported that repetitive movements and activities, prolonged static positioning, forceful exertions and non-neutral body postures have been identified as key risk factors for MSDs[28,29]. The bell metal workers were found to have repetitive movements as well as static positioning of different body parts during performing the task.

CONCLUSION

From this study it can be concluded that long-term bell metal workers, who adopt awkward posture for prolonged periods, have severe musculoskeletal pain. The prevalence of MSDs exhibited variation in the participants having different work bell metal jobs. Prolonged years at service and overwork also have significant impact on the prevalence of MSD. The postures adopted by the workers had risk levels from 'low' to 'very high' in different tasks of bell metal job especially in Smelting and hammering/scraping. Continuous pressure load was acted on thighs with repetitive motion which compressed the thigh muscle and sciatic nerve and that might be the causes of pain/discomfort in the thigh.

LIMITATIONS

The bell metal work is a clustered based survey and therefore is not a true indicator of community prevalence of MSD. The study had the limitations which are associated with cross - sectional studies, unlike that of case control studies; the result could not confirm any casual relationship between ergonomic risk factors and MSDs. We studied on male bell metal workers only rather than female workers. Cluster sampling from many industries would have been a better representation of the study group rather than the random sampling from a limited number of industries.

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