Musculoskeletal health problems and relationship of risk factors among manual clay brick sector workers

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Abstract: Adverse working conditions with prolonged awkward postures and traditionally designed hand tools result in musculoskeletal health problems among brick kiln workers. The occurrence of musculoskeletal problems depends on various physiological and work-related factors. The present cross-sectional study aims to determine the prevalent musculoskeletal health issues among 150 manual clay brick sector workers and the relationship of risk factors with these issues. Random sampling survey using modified Nordic questionnaire and postural assessment methods, rapid entire body assessment (REBA) and rapid upper limb assessment (RULA) were used for data collection. The association between prevalence of MSDs and risk factors was determined by binary logistic regression. Most prevalent musculoskeletal issues were found in shoulder (56.15%), wrist (50.77%) and lower back (50%) regions. Musculoskeletal issues were found to be associated with personal and work-related factors. The average REBA and RULA scores for all tasks indicated high postural risk. The outcomes of the study pointed out the need for ergonomic interventions to reduce the issues among kiln sector workers.

Keywords: brick; business; health; musculoskeletal; posture; regression; risk factors; workers.

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1 Introduction

Fired clay brick manufacturing sector has been emerged as an important sector in developing countries. In developing economies, fast-growing population and urbanisation have caused a hike in infrastructure and construction industry. The Government of India initiative Pradhan Mantri Awas Yojana to meet the existing deficit of 20 million houses and development of 100 smart cities are expected to the key growth drivers for the clay brick business in the country. In India, fired clay bricks are manufactured in traditional kilns categorised as unorganised small-scale sector (Bandyopadhyay and Sen, 2016; Sett and Sahu, 2014). The Indian unorganised sector employs about 4,575 lac peoples (NCEUS, 2007) including employment to around 100 lac workers by fired clay brick making sector. India is second largest clay brick producer in the world having more than 1.40 lac brick units (Das, 2014; Kamyotra, 2015). This sector in India is unorganised, and most of the brick production work is performed manually with traditional methods. The number of workers in this sector is considerably high in India, but the actual data concerning the number of people employed, occupational health and safety, their social life and other work-related issues are not available (Das, 2014; Kamyotra, 2015; Kumbhar et al., 2014; Sett and Sahu, 2014; Bandyopadhyay and Sen, 2014).

The brick kiln workers work eight to ten hours per day in prolonged repetitive and awkward postures with the help of traditional hand tools. Continuous working in an awkward posture with traditionally designed hand tools, repetitive loads and un-ergonomic work system result in musculoskeletal disorders (MSDs) and other occupational health problems among brick kiln workers. Due to MSDs and other work-related health issues, most of the workers do not stay in the same job for long (Bandyopadhyay and Sen, 2016; Cooper and Kleiner, 2001; Singh et al., 2012; Trevelyan and Haslam, 2001).

MSDs are common health problems all over the world and are leading causes of frustration, dissatisfaction and low efficiency of workers (Jain et al., 2018b; Sain and Meena, 2016; Punnett and Wegman, 2004). In today's business world, the well-being of workers has emerged as a crucial issue in most of the developed and developing countries. In most of the organised sectors, safety at work and workers comfort is considered as a key to improving the productivity and quality of the product. The musculoskeletal issues can be minimised by reducing the biomechanical and psychosocial load through proper work system design (Ahasan and Imbeau, 2003; Niu, 2010; Roper and Yeh, 2007; Shariat et al., 2017).

The manual brick kiln workers neither undergo any formal training nor are they sufficiently aware of safety at work. Hence, to enhance the musculoskeletal health of brick kiln workers, it is essential to analyse musculoskeletal symptoms and the associated causal factors, and to develop some ergonomic interventions. This study thus aims to evaluate the prevalence of MSDs among clay brick kiln workers and investigates any possible association between risk factors and the development of MSDs.

1.1 Literature review

Previous studies revealed that work-related musculoskeletal issues result in increased absenteeism, lost working time, increased probability of accidents and errors, higher job transfer, decreased productivity, low-quality work and high administrative and personnel costs (Cardinali, 1998; Jain et al., 2018b; Niu, 2010; Widanarko et al., 2012). In labour-intensive industries, more than 70% of the total expenditure is incurred in the wages, which ultimately affects the business of the company. These problems can be minimised by ergonomic interventions for the better occupational health of workers (Ahasan and Imbeau, 2003; Niu, 2010; Roper and Yeh, 2007; Shariat et al., 2017).

A significant reduction in musculoskeletal issues (Shariat et al., 2017), improvement in productivity (Govindaraju et al., 2001; Megeid et al., 2011; Yeow and Sen, 2006) and cost benefits (Guimarães et al., 2012; Lahiri et al., 2005; Tompa et al., 2013) can be achieved through properly designed ergonomic interventions. Most of the research work in the unorganised sectors in the Indian context related to occupational health and ergonomic intervention has been carried out in the agriculture sector (Borah and Kalita, 2012; Gite, 1991; Jain et al., 2018a; Khidiya and Bhardwaj, 2012; Kishtwaria and Rana, 2012; Mehta et al., 2012; Nag et al., 1988). Some work has also been reported in handicraft sector (Das et al., 2018; Meena et al., 2014a, 2014b; Mukhopadhyay and Srivastava, 2010). In other unorganised industries, very little work has been reported. Ergonomic studies on clay brick manufacturing system conducted so far in India are very limited. The previous studies on brick kiln sector focused on nutrition status, energy requirement and grip strength of workers (Bandyopadhyay and Sen, 2016; Sett and Sahu, 2016), heat exposure (Das, 2018; Sett and Sahu, 2014), respiratory symptoms (Monga et al., 2012), lower back pain (Das, 2015) and physical stress (Das, 2014). Very few studies investigated the prevalence of MSDs in different body regions and associated factors within the workers involved in various manual activities of clay brick manufacturing. After doing the extensive literature review, it was observed that the exploratory studies on musculoskeletal symptoms in different body regions among kiln workers are limited. Also, significant work has not been addressed on the relationship of prevalence of MSDs and risk factors in this particular sector.

2 Methodology

A cross-sectional study based on random sampling survey using a modified version of standard Nordic questionnaire (Kuorinka et al., 1987) was conducted for data collection. The questionnaire was modified with the help of the experts and on the basis of initial field survey. The provision of hand dominance was removed from the questionnaire as both hands are simultaneously used by the works. Those body parts in which issues were reported in initial survey taken in questionnaire. Some other information regarding smoking habits, educational status were also incorporated. A total of 150 (97 male and 53 female) workers from 20 brick kilns situated in Eastern and Northern regions of Rajasthan, India involved in manual spading (clay excavation and preparation), mould filling, mould evacuating, and brick carrying tasks participated in the study. In the questionnaire, information about demographic (age, gender, height, weight, etc.), work-related aspects (type of work, work experience, duration of work, etc.) and musculoskeletal symptoms (presence of pain and discomfort in various body parts) was collected from the workers. Before approaching and enlisting the workers, prior permission was taken from kiln managers/owners. It was ensured that no aspect of the study was in any way in violation of the National Ethical Guidelines for Biomedical and Health Research Involving Human Participants of Indian Council of Medical Research (2016). Data were analysed using the software package: Minitab (version 16.0). The association between prevalence of MSDs and risk factors was determined using binary logistic regression. The occurrence of musculoskeletal symptoms in a body region was used as the dependent variable, and personal and work-related aspects were used as independent variables. The worker involved in excavation and preparation of clay by spading, mould filling, mould evacuating and brick carrying tasks were found to be exposed to highly awkward posture during the quick observation. Hence, the 75 workers involved in these tasks were randomly selected from survey population of 150 workers for further analysis. Postures were analysed by visualisation, photographs and video recordings and then rapid entire body assessment (REBA) and rapid upper limb assessment (RULA) score methods were used to find out the severity of the postural risks (Hignett and McAtamney, 2000; McAtamney and Corlett, 1993).

3 Data analysis and results

3.1 Demographic data of workers

Table 1 shows the demographic data of survey population (i.e., brick kiln industry workers). As can be observed, 60% of the brick kiln workers belong to the age group of 21–30 years. A few workers are below 20 years of age too. 57.33% workers have less than five years of work experience in the same field. Only 2% of workers have more than ten years of experience. This can be attributed to the fact that due to MSDs and other health issues, workers generally change their job after some time.

Table 1 Characteristics of the survey population

Characteristics		*Number of workers (N = 150)*	*Percentage (%)*
Age (in years)	≤ 20	11	7.33
	21–30	90	60.00
	31–40	27	18.00
	41–50	21	14.00
	> 50	1	0.67
Gender	Male	97	64.67
	Female	53	35.33
Work experience (in years)	< 5	86	57.33
	5–10	61	40.67
	> 10	3	2.00
Task	Spading	47	31.33
	Mould filling	61	40.67
	Mould evacuating	22	14.67
	Carrying	20	13.33
Weight (in kg)	≤ 50	17	11.33
	51–60	63	42.00
	61–70	65	43.33
	> 70	05	03.33
Height (in cm)	≤ 160	18	12.00
	161–170	83	55.33
	> 170	49	32.67

3.2 MSDs among workers

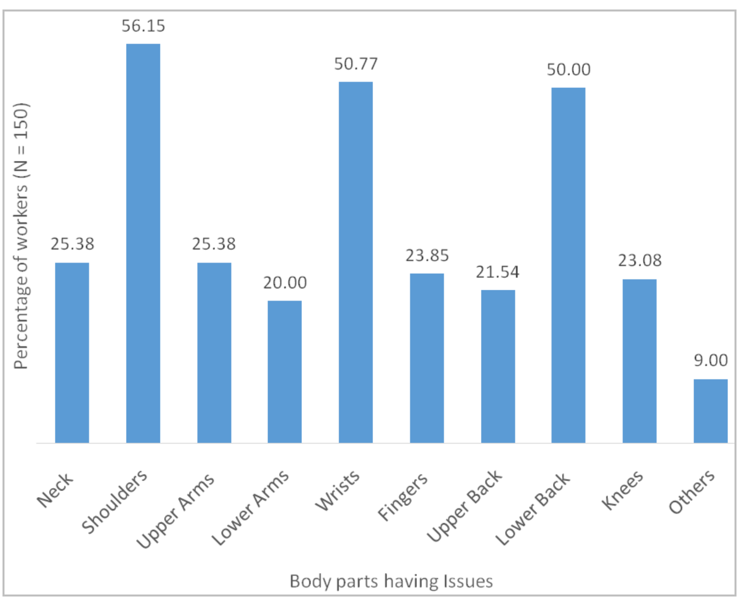
Most of the health problems among brick kiln workers arise from ergonomic risk factors, mostly awkward working postures, long working hours, advanced age of workers and exertion of high levels of forces. Figure 1 shows the prevalence of MSDs in different body regions of workers. The most commonly affected body portions reported by the workers were shoulders, upper arms, wrists, fingers, lower back and knees.

Maximum issues reported were related to the shoulder regions. About 56.15% of brick kiln workers reported shoulder pain and other shoulder related issues. The musculoskeletal symptoms in wrist regions were reported by 50.77% of workers, while 50% of the workers were found with problems in lower back region. Other issues related to neck (25.38%), upper arm (25.38%), fingers (23.85%), knees (23.08%), upper back (21.54%) and lower arm (20%) as reported by the workers were also found to be significant.

3.3 Association between risk factors and MSDs

The association between MSDs in certain body parts with a set of risk factors including personal and work-related factors are depicted in Table 2 and Table 3. The symptoms of MSDs in neck region were found to be more prominent with increment in worker's age (OR = 1.22, 95% CI: 1.06–1.41, p = 0.006). Among the workers involved in mould filling task, prevalence of neck (OR = 0.19, 95% CI: 0.040–0.970, p = 0.046) and shoulder (OR = 0.280, 95% CI: 0.100–0.750, p = 0.011) MSDs were lower as compared to spading task workers. Whereas, wrist related issues were highly associated (OR = 2.67, 95% CI: 1.01–7.05, p = 0.048) with mould filling workers. Mould evacuating task was found to be a strong contributing factor in MSDs of wrists (OR = 5.47, 95% CI: 1.38–21.47, p = 0.016) and fingers (OR = 9.63, 95% CI: 1.92–48.20, p = 0.006). Prevalence of MSD symptoms in lower back region (OR = 0.14, 95% CI: 0.03–0.64, p = 0.011), neck (OR = 0.280, 95% CI: 0.01–0.89, p = 0.039) and shoulders (OR = 0.110, 95% CI: 0.030–0.430, p = 0.002) were lower in mould evacuating workers as compared to spading task workers. The brick carrying task was significantly associated with occurrence of MSDs in neck (OR = 28.99, 95% CI: 3.26–257.65, p = 0.003) and lower arm (OR = 11.85, 95% CI: 1.94–72.51, p = 0.007) regions. The issues related with lower back (OR = 0.12, 95% CI: 0.02–0.88, p = 0.037) and shoulder (OR = 0.070, 95% CI: 0.010–0.380, p = 0.002) were lower in brick carriers as compared to spading task workers.

Figure 1 Reported musculoskeletal issues among workers (see online version for colours)



Work experience in present job was also recognised as a significant contributing factor for occurrence of MSDs in upper arms (OR = 1.93, 95% CI: 1.21–3.08, p = 0.006), wrists (OR = 1.85, 95% CI: 1.23–2.80, p = 0.003), fingers (OR = 1.96, 95% CI: 1.26–3.05, p = 0.003), lower back (OR = 2.06, 95% CI: 1.29–3.30, p = 0.003) and knee (OR = 2.29, 95% CI: 1.39–3.78, p = 0.001) regions.

Table 2 Relation between risk factors and MSDs in neck, shoulder, upper arm and lower arm

Body part with MSDs		*Neck (n = 33)*				*Shoulder (n = 73)*				*Upper arm (33)*				*Lower arm (26)*			
		P value	*Odds ratio*	*95% CI*		*P value*	*Odds ratio*	*95% CI*		*P value*	*Odds ratio*	*95% CI*		*P value*	*Odds ratio*	*95% CI*	
Factor				*Lower*	*Upper*			*Lower*	*Upper*			*Lower*	*Upper*			*Lower*	*Upper*
Age		*0.006**	1.22	1.06	1.41	0.943	1.000	0.900	1.120	0.538	0.960	0.860	1.080	0.267	1.06	0.95	1.19
Gender	Male																
	Female	0.185	4.19	0.50	34.92	0.475	0.610	0.160	2.360	0.807	1.260	0.190	8.280	0.422	0.47	0.08	2.96
Weight		0.438	2.41	0.26	22.16	0.743	0.790	0.200	3.170	0.658	1.510	0.240	9.470	0.860	1.19	0.18	7.97
Height		0.488	0.57	0.12	2.79	0.663	1.250	0.460	3.430	0.724	0.780	0.200	3.040	0.772	0.82	0.21	3.23
BMI		0.499	0.12	0.00	59.24	0.812	1.600	0.030	77.570	0.682	0.340	0.000	58.140	0.876	0.65	0	133.98
Task	Spading																
	Mould filling	*0.046**	0.19	0.04	0.97	*0.011**	0.280	0.100	0.750	0.954	1.040	0.320	3.390	0.672	0.74	0.18	3
	Mould evacuating	*0.039**	0.09	0.01	0.89	*0.002**	0.110	0.030	0.430	0.501	0.530	0.080	3.390	0.326	2.31	0.44	12.36
	Carrying	*0.003**	28.99	3.26	257.65	*0.002**	0.070	0.010	0.380	0.477	0.450	0.050	4.090	*0.007**	11.85	1.94	72.51
Work experience		0.060	1.63	0.98	2.72	0.059	1.450	0.990	2.150	*0.006**	1.93	1.21	3.08	0.114	1.41	0.92	2.15
Average working hours		0.255	0.62	0.27	1.41	0.556	0.870	0.550	1.380	0.328	0.740	0.400	1.360	0.807	1.09	0.56	2.1
Smoking habit		0.679	0.750	0.190	2.980	0.241	1.870	0.660	5.290	*0.024**	3.810	1.200	12.120	0.820	0.87	0.25	2.98
Rest duration		0.663	0.370	0.000	33.060	*0.027**	45.640	1.530	1,357.010	0.341	6.670	0.130	332.940	0.271	0.12	0	5.39

Notes: n: Number of workers having musculoskeletal issues. CI: Confidence interval and p: significance value.*Significant at $p < 0.05$.

Table 3 Relation between risk factors and MSDs in wrist, finger, upper back, lower back and knee

Body part with MSDs		*Wrist (n = 66)*				*Finger (n = 31)*				*Upper back (n = 28)*				*Lower back (n = 65)*				*Knee (n = 34)*			
		P value	*Odds ratio*	*95% CI*		*P value*	*Odds ratio*	*95% CI*		*P value*	*Odds ratio*	*95% CI*		*P value*	*Odds ratio*	*95% CI*		*P value*	*Odds ratio*	*95% CI*	
Factor				*Lower*	*Upper*			*Lower*	*Upper*			*Lower*	*Upper*			*Lower*	*Upper*			*Lower*	*Upper*
Age		0.872	0.99	0.89	1.1	0.293	0.94	0.84	1.05	0.467	1.06	0.91	1.23	0.774	1.02	0.9	1.15	0.487	0.96	0.85	1.08
Gender	Male		1.00				1.00				1.00				1.00				1.00		
	Female	0.813	1.17	0.31	4.45	0.692	1.45	0.23	9.05	0.319	2.82	0.37	21.74	0.376	0.5	0.11	2.33	*0.039**	6.67	1.1	40.56
Weight		0.176	2.75	0.64	11.86	0.124	4.03	0.68	23.88	0.303	3.58	0.32	40.43	0.964	1.04	0.23	4.75	0.718	1.4	0.23	8.67
Height		0.202	0.5	0.17	1.45	0.114	0.35	0.09	1.29	0.44	0.51	0.09	2.82	0.869	0.91	0.3	2.78	0.791	0.84	0.22	3.16
BMI		0.196	0.07	0	4.03	0.173	0.03	0	4.44	0.284	0.02	0	23.91	0.941	1.17	0.02	79.95	0.809	0.54	0	83.84
Task	Spading		1.00				1.00				1.00				1.00				1.00		
	Mould filling	*0.048**	2.67	1.01	7.05	0.445	0.62	0.18	2.14	0.643	0.71	0.16	3.07	0.141	0.47	0.17	1.28	0.332	1.79	0.55	5.79
	Mould evacuating	*0.016**	5.47	1.38	21.74	*0.006**	9.63	1.92	48.2	0.919	0.91	0.15	5.43	*0.011**	0.14	0.03	0.64	0.205	0.27	0.03	2.06
	Carrying	0.195	0.29	0.04	1.89	0.483	2.04	0.28	14.93	*0.002**	25.94	3.41	197.15	*0.037**	0.12	0.02	0.88	0.887	1.15	0.16	8.23
Work experience		*0.003**	1.85	1.23	2.8	*0.003**	1.96	1.26	3.05	0.156	1.43	0.87	2.34	*0.003**	2.06	1.29	3.3	*0.001**	2.29	1.39	3.78
Average working hours		0.736	0.92	0.58	1.47	0.225	0.69	0.37	1.26	0.864	0.94	0.48	1.85	0.064	0.61	0.36	1.03	0.836	0.94	0.52	1.7
Smoking habit		0.589	0.73	0.24	2.25	0.667	1.32	0.38	4.59	*0.007**	0.12	0.02	0.56	0.054	0.3	0.09	1.02	0.212	2.13	0.65	7.03
Rest duration		0.944	1.11	0.07	18.65	0.55	3.38	0.06	184.36	0.704	0.47	0.01	22.91	0.25	8.65	0.22	339.77	0.767	0.59	0.02	19.88

Notes: n: Number of workers having musculoskeletal issues. CI: Confidence interval and p: significance value. *Significant at $p < 0.05$.

3.4 Posture analysis

Awkward body postures acquired by brick kiln workers during spading, mould filling, mould evacuating and carrying tasks were analysed by REBA and RULA score methods. The average REBA scores for spading, mould filling, mould evacuating and carrying tasks were found to be 11.34, 10.80, 10.10 and 10, respectively. The REBA score for spading task lies in the category of very high risk (i.e., > 11), and so ergonomic changes must be implemented. Also, the REBA scores for mould filling and mould evacuating fall under the high-risk category indicating an urgent need for further investigation and ergonomic changes. The average RULA scores calculated for spading, mould filling, mould evacuating and carrying tasks were 6.40, 5.86, 5.32 and 5.20, respectively. The scores lie in the rage of 5–6, indicating the requirement of further investigation and ergonomic changes.

4 Discussion

In the present study, majority of the clay brick sector workers were found in the age group of 21–30 years as this occupation demands high physical strength. Some past Indian researches (Bandyopadhyay and Sen, 2016; Sett and Sahu, 2016) have also reported the approximately same age group of brick kiln workers. On the other hand, some Indian studies like Das (2014) have even reported higher age (33.5 ± 6.2 years) of workers in the same sector.

More than half of the surveyed workers were found having shoulder-related issues. The possible reason behind shoulder issues could be repetitive work with a considerable load for long periods, particularly in spading and carrying tasks. Wrist and lower back problems were also found among half of the workers surveyed, and the possible reasons are repetitive wrist movement and repetitive bending of the back without following any ergonomic principles. Comparable results were reported by Jain et al. (2018a) and Gangopadhyay and Dev (2014) in their studies on farm workers involved in the spading task with bent trunk and crop cutting in squatting posture with repetitive wrist movements. These tasks are quite similar to the spading and mould filling activities in manual clay brick making occupation.

Outcomes of binary logistic regression showed that with advancement of age, the risk of MSDs also grows. Some other Indian studies (Das et al., 2018; Jain et al., 2018a; Sett and Sahu, 2016) have also reported age as an important contributing factor for prevalence of MSDs. Type of manual activity performed by the workers was also found as a significant contributing factor for MSDs in different body regions. The workers having greater work experience were more prone to MSDs in wrist, finger, lower back and upper arm regions. Comparable results were reported by Das et al. (2018) in a study on Indian population. No significant effect of gender on MSD symptoms was observed. REBA and RULA scores for all tasks were found to be very high, and the possible reasons are awkward postures due to un-ergonomically designed traditional hand tools, lack of awareness of ergonomic principles and adverse working conditions.

5 Conclusions

From the present study, it was concluded that traditional clay brick production is a high-risk job, and prone to MSDs among workers. Workers prefer this occupation in their young age only and migrate to other sectors due to musculoskeletal issues. According to the results of the questionnaire, survey workers were found suffering from work-related musculoskeletal issues in different body parts. Shoulders, wrists and lower back were most reported body regions with MSDs.

Also, posture analysis indicated high levels of postural risk. Binary logistic regression proved that personal factors including age, gender and BMI; and occupational factors including experience and task type affect the occurrence of MSDs in one or more body parts among the workers. The association of risk factors with the prevalence of MSDs in specific regions were found significant. Hence, there is an urgent requirement of ergonomic intervention to improve the musculoskeletal health of kiln workers. Ergonomically designed hand tools and personal protection aids along with techniques like job rotation must be implemented to minimise the occurrence of MSDs and to improve the overall occupational health level. The improved work life of brick kiln workers would also increase the productivity of industry. With further exploration, the findings of current study may be helpful in developing strategies for ergonomic interventions and preventive measures to minimise musculoskeletal issues among clay brick kiln workers.

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