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Original Article

Identifying musculoskeletal issues and associated risk factors among clay brick kiln workers

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Abstract: The present study is aimed to investigate the musculoskeletal issues and association of risk-factors with these problems among manual brick kiln workers. A modified Nordic Questionnaire was administered among 376 traditional brick kiln workers to collect data. Logistic regression was used to determine the association between musculoskeletal problems and risk-factors. Majority of workers (76.19%) involved in mould evacuating task reported wrist issues whereas lower back issues were reported by 62.35% of spading task workers. Age was a factor associated with musculoskeletal symptoms in the majority of the body regions. Gender was significantly associated with lower back (OR=3.71, CI: 1.51–9.11) MSDs. Spading task was associated with the wrist (OR=2.42, CI: 51.03–5.66), and lower back (OR=3.97, CI: 1.75–8.98) problems. Mould filling was a contributing factor for the wrist (OR=4.27, CI: 1.81–10.09) and knee (OR=6.88, CI: 2.40–19.70) issues. MSDs in wrist (OR=12.22, CI: 4.82–30.98) and fingers (OR=3.57, CI: 1.23–10.36) were significant in mould evacuating workers. Workers having less than 5 yr of experience were less prone to the neck (OR= 0.03, CI: 0.00–0.72) and upper back (OR=0.08, CI: 0.01–0.76) MSDs. For prevention of problems, ergonomic interventions such as workers' training, use of protecting aids, modification in hand tools and work practices are needed.

Key words: Brick kiln, Ergonomics, Logistic regression, Musculoskeletal disorders, MSDs, Risk factors

Introduction

Fired clay brick is a widely used construction material worldwide. The clay brick making process in India includes a large number of manual activities of repetitive nature which are continuously performed in awkward postures with traditional hand tools[1)]. Indian fired clay brick kilns are categorised as unorganised small-scale industries[2, 3)]. The unorganised sector in India hires approximately 458 million workers including around 10 million people in fired clay brick kilns[4)]. India is the world's second largest brick producer and has more than 140 thousand brick kilns[5–7)]. A pictorial view of clay brick industry status in India and its neighbouring countries in the year 2015 is shown in Fig. 1.

As per the report of Kamyotra[6)], the contribution of India in the world's clay bricks production is 13%, which is just after China (23%). Despite its importance in the economy, the Indian clay brick manufacturing sector is not as modern as it should be. In India, about 99% clay brick production work is done manually with traditional methods[1, 5, 8)]. Various tasks involved in clay brick manufacturing with the working postures and working conditions are presented in Fig. 2.

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In the first step, clay is quarried using some manual digging tools such as spade, mattock, etc. and then broken into small pieces with the help of a mallet. In the second step, clay is prepared by wetting and then mixing either manually or with the help of a spade. The prepared clay is then cut into clots by hands. Sometimes a covering of coal dust is also provided on prepared clots to avoid sticking of clay on moulding boxes. This also helps in better burning of bricks. In the next step, the clot is filled into the moulding box, and green brick is evacuated on the ground. After some days, bricks are stacked to dry and then dried bricks are carried to the kiln and arranged for firing. After some days, fired bricks become ready.

In this industry, most of the workers are uneducated. Moreover, there is a serious lack of proper professional training and awareness regarding safe and healthy work practices. Working in adverse conditions results in various health issues and musculoskeletal disorders (MSDs) among brick kiln workers[3, 5]. Working in continued repetitive and awkward postures has been recognized as a significant occupational risk factor emergent in various manual small-scale industries (i.e., agriculture, apparel, construction, furniture, handicraft, etc.) worldwide[9–13]. Repetitive work in prolonged awkward postures is associated with discomfort, fatigue, health problems and MSDs among workers[14–16]. Work-related MSDs and other health problems result in increased absenteeism, accidents, higher turnover of workers and decreased productivity[17–19]. Ergonomic interventions (i.e., work system and hand-tool redesign, job rotation, training on ergonomic principles, etc.) are the best ways to reduce MSDs among workers and to improve productivity[2, 12, 16, 20, 21]. Exploration of occupational health issues and associated factors is the first stage towards designing the work environment ergonomically[16, 22, 23].

In India, many studies in the brick manufacturing sector have been conducted. Most of these studies were focussed on testing the nutrition status[24], heat exposure[3], respiratory symptoms[25], lower back pain[26] and physical stress[5] of the workers. To date, limited studies have investigated prevalence of musculoskeletal issues in different body parts and associated factors among the workers involved in various manual clay brick manufacturing tasks. To fill this gap, the present study is focussed on:

a. Analyzing the occurrence of musculoskeletal problems among manual clay brick kiln workers.

b. Identifying the level of postural risks for selected brick making tasks.

c. Determining the association of musculoskeletal symptoms with various risk factors.

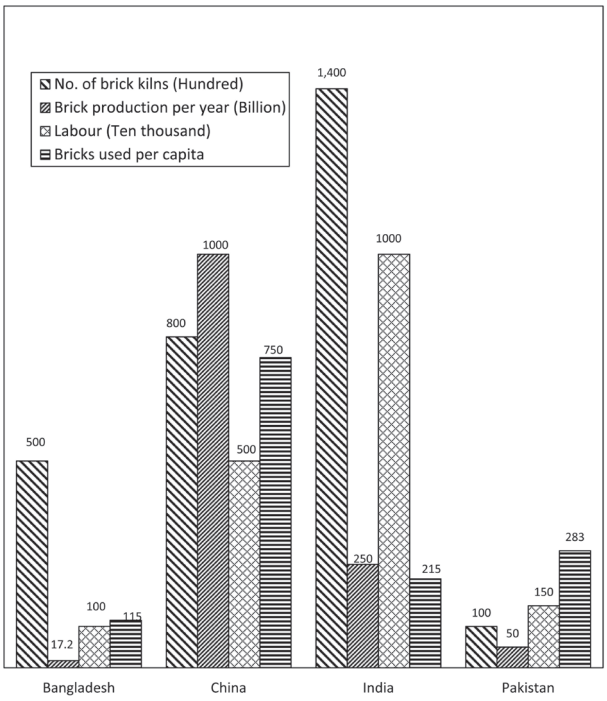

Fig. 1. Status of brick industry in India and neighbouring countries.

Materials and Methods

Study region and sampling

The present study was conducted among workers employed in traditional fired clay brick manufacturing units (kilns) situated in the state of Rajasthan, India. Initially, 490 workers from 32 brick kilns were approached to participate in the study. Prior permission for this task was sought from associated brick kiln owners and managers. Among the brick kiln units that were approached, the owners of 10 brick kilns refused to participate, and a total of 400 participants from 22 were listed for the study. Out of these listed workers, 24 did not turn up to fill the questionnaire. Remaining 376 participants agreed to fill out the questionnaire. Out of the filled questionnaires, 48 were not filled completely. Finally, data obtained from 328 workers was considered for further analysis. The workers involved in spading, mould filling, mould evacuating and brick carrying tasks were selected randomly after careful observation of these tasks during the initial visits to the kilns.

This duration of this study was from January 2016 to June 2017. In Rajasthan, brick manufacturing is generally done from November to June. During this period, possibility of rain remains low. Prior approval from the departmental ethical research committee of the university was

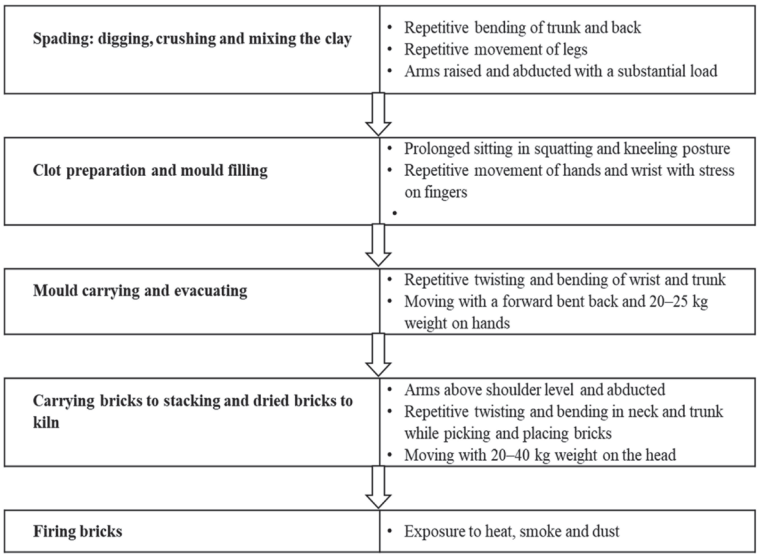

Fig. 2. Steps of brick making process with working postures.

taken for this study. Written consents from workers and kiln managers/owners were taken before the study, and it was ensured that no aspect of the study was in any way in violation of the Helsinki guidelines[27].

Questionnaire development

A structured questionnaire based on Standard Nordic Questionnaire (SNQ) was used to collect the demographic and musculoskeletal health-related data of the workers. To modify the questionnaire, a pilot study among 50 brick kiln workers was conducted using Standard Nordic Questionnaire[28]. Additional space for comments was provided in the SNQ. Body parts, namely, elbows, hips, thighs and ankles were removed from the modified questionnaire as the issues in these body parts were reported by only a few (≤5%) workers. Also, some body parts namely, upper arm, lower arm and fingers were included in the questionnaire as more than 20% of workers reported musculoskeletal symptoms in these body regions. In most of the clay brick manufacturing activities (namely spading, clot cutting, mould filling, mould evacuating, etc.) both the hands are used simultaneously. Majority of workers (96%) included in the pilot survey reported similar issues for both right and left body parts. Hence, questions related to issues on right and left sides were removed from the questionnaire. Provision for personal and work-related factors was also modified with the consultation of experts. The questionnaire was finalised after consultation with the three experts. The modified questionnaire was divided into three portions: (i) demographic variables (i.e., age, height, weight, gender, qualification, smoking habits, etc.), (ii) work-related characteristics (i.e. type of task, experience, working hours, rest duration, etc.) and (iii) body parts having musculoskeletal symptoms including pain and/or discomfort. In the third part, the workers were asked whether they felt pain or discomfort in one or more body parts, and the responses were recorded in the form of '0' (no) or '1' (yes). As the majority of workers were less educated and didn't know English language, the questionnaire was translated into the Hindi language. The workers were also helped by the surveyor in filling the questionnaires.

Postural assessment

During the initial study, it was observed that the workers used both upper and lower extremities during different brick making tasks[29]. Therefore, Rapid Upper Limb Assessment (RULA)[30] as well as Rapid Entire Body Assessment (REBA)[31] methods were used to analyse the postures of 154 workers involved in spading (excavating clay and preparing mud), clot cutting and mould filling, mould evacuating and brick carrying tasks. These workers were randomly selected from the 328 survey participants. These techniques are inexpensive and easy to conduct compared to other observational techniques. Hence these methods are widely used by professionals for postural analysis in manual working[32, 33]. The postures were observed carefully during work sessions, and scores were entered in the RULA and REBA score sheets.

Analysis of data

The demographic characteristics (i.e., age, weight, height, body mass index (BMI), gender, work experience, etc.) and work variables (working hours, work experience, the task performed, etc.) were categorised and tabulated. For data analysis, IBM SPSS software (version 22) was used.

To explore the factors causing musculoskeletal problems, binary and multinomial logistic regressions were used. The significance level at $p<0.05$ and odds ratios (OR) with confidence intervals (CI) were calculated. Age, gender, BMI, work experience, and tasks were considered as independent variables whereas musculoskeletal symptoms in the neck, shoulders, upper arms, lower arms, wrists, fingers, upper back, lower back and knee regions were considered as dependent variables. The risk factors having significant associations with musculoskeletal symptoms in the binary logistic regression analysis were analysed again by multinomial logistic regression method at $p<0.05$. The reference response was taken as '1' for presence of musculoskeletal symptoms. Hosmer-Lemeshow test for goodness of fit was used for checking the correctness of the binary logistic regression model.

Results

Characteristics of participants

Socio-demographic and work-related characteristics of brick kiln workers were collected through the questionnaire survey. The characteristics of the kiln workers (N=328) obtained from the survey are exhibited in Table 1. It was observed that most of the workers (57.62%) were in the age group of 21–30, while some workers (8.55%) were below 20 yr of age. The age range of participants in the present study was 17 to 53 yr.

BMI data showed that most of the workers (82.01%) were of normal weight, 15.85% of the workers were underweight, and only a few (2.14%) were overweight. It was found that 50% of the workers had less than 5 yr of experience and only 1.52% of the workers had more than 10 yr of experience. From these facts, it could be inferred that the workers do not tend to stay in this type of job for a long time. The number of male respondents (66.16%) considered in the study was more than the number of female respondents (33.84%).

Musculoskeletal issues among workers

Most of the MSDs among brick kiln workers arise from ergonomic risk factors, mostly awkward working postures and repetitive motion with a load. Table 2 shows the prevalence of musculoskeletal symptoms in different body parts of the workers. The most commonly affected body parts were wrists, lower back and shoulders. Musculoskeletal issues in wrist region were reported by maximum number (51.52%) of workers. The workers with pain and discomfort in lower back and shoulder were found to be 50% and 47.87% respectively.

The musculoskeletal issues for different tasks (i.e., spading, mould filling, evacuating and carrying) are depicted in Table 2. The problems in the lower back region were stated by majority of workers (62.35%) performing the spading task. About 57.65% of workers were found having shoulder problems, whereas 42.35% workers reported issues in wrist regions. Among the workers involved in mould filling task, the maximum number of workers (55.79%) reported finger related problems. Wrist related issues were found in 53.68% workers while 42.11% workers reported shoulder problems. Majority of workers (76.19%) involved in mould evacuating task reported symptoms related to wrist regions followed by musculoskeletal issues in the lower back region (55.95%). Musculoskeletal problems in shoulder area were found in 53.13% of the brick carriers, whereas upper back issues were reported by 45.31% of the workers.

Posture analysis

The body postures acquired by workers during spading, mould filling, mould evacuating and brick carrying tasks were analysed by direct observational techniques, i.e., REBA and RULA. Table 3 shows the REBA and RULA scores and the level of postural risk.

The average REBA scores for spading, mould filling, mould evacuating and brick carrying tasks were 11.71 ± 0.80, 11.10 ± 0.82, 10.50 ± 0.72 and 10.00 ± 0.81 respectively. The REBA scores for spading and mould filling tasks were found to lie in the category of 'very high risk' (i.e., REBA score >11). The average REBA and RULA scores for different tasks are depicted in Fig. 3.

The average RULA scores also revealed similar severity of occupational risks as found in REBA assessment. The RULA scores for spading, mould filling, mould evacuating and carrying tasks were 6.40 ± 0.64, 6.05 ± 0.76, 5.24 ± 0.74 and 5.00 ± 0.85 respectively. The scores for spading and mould filling tasks lie in the high-risk category (6–7). The REBA and RULA scores clearly indicate that there is an immediate requirement of intervention in the related tasks. From the scores obtained for mould evacuating and carrying tasks, it was concluded that further investigation and ergonomic changes were needed.

Table 1. Characteristics of brick kiln workers (N=328)

Characteristics	Category	Number of workers	Percentage (%)
Age (yr)	≤20	28	8.55
	21–30	189	57.62
	31–40	62	18.90
	41–50	40	12.19
	≥51	09	2.74
Weight (kg)	≤45	03	0.91
	46–55	93	28.35
	56–65	148	45.12
	66–75	80	24.39
	>75	04	1.22
Height (m)	<1.60	08	2.44
	1.60 –170	136	41.46
	170.10–180	169	51.52
	>180	15	4.57
Body Mass Index (BMI)	<18.50	52	15.85
	18.50–24.99	269	82.01
	25–29.99	07	2.14
	≥30	00	00
Gender	Male	217	66.16
	Female	111	33.84
Education status	Illiterate	185	56.40
	Literate only	108	32.93
	Secondary	27	8.23
	Senior secondary	06	1.83
	Graduate	02	0.61
Smoking habit	Smokers	95	28.96
	Nonsmokers	233	71.04
Work experience (yr)	<5	164	50.00
	5–10	159	48.48
	>10	05	1.52
Task	Spading	85	25.92
	Mould filling	95	28.96
	Mould evacuating	84	25.61
	Carrying	64	19.51

Association between risk factors and musculoskeletal symptoms

Binary logistic regression

Binary logistic regression was applied to identify the relationship between musculoskeletal issues and personal and work-related factors. The association between musculoskeletal symptoms in different body parts with demographic and occupational factors are shown in Table 4 and 5. Age was found to be substantially associated with the musculoskeletal problems in all body regions except for the upper back region. Gender was observed as a significant contributing factor for the occurrence of MSDs in fingers and lower back. Finger issues were lesser in males (OR=0.26, 95% CI: 0.09−0.73, p=0.01) while lower back problems were more (OR=3.71, 95% CI: 1.51−9.11, p=0.00) compared to females. The underweight workers (i.e., BMI <18.5) were more prone to shoulder related issues (OR=23.37, 95% CI: 1.81–301.36, p=0.02) as compared to overweight workers (i.e., BMI >25).

The type of task performed by the workers was also a causal factor for the generation of MSDs. Spading task showed significant association with wrist (OR=2.42, 95% CI: 51.03−5.66, p=0.04), upper back (OR=0.16, 95% CI: 0.06−0.40, p=0.00) and lower back (OR=3.97, 95% CI: 1.75−8.98, p=0.00) problems. Mould filling task was recognised as a substantial contributing factor for musculoskeletal issues in wrist (OR=4.27, 95% CI: 1.81−10.09, p=0.00), finger (OR=17.56, 95% CI: 5.90−52.31, p=0.00), and knee

Table 2. Overall and task-wise occurrence of musculoskeletal issue

Body parts having issues	Percentage of total workers (N=328)	Percentage of task-wise workers			
		Spading (n=85)	Mould filling (n=95)	Mould evacuating (n=84)	Carrying (n=64)
Neck	18.90	21.18	14.74	13.10	29.69
Shoulder	47.87	57.65	42.11	40.48	53.13
Upper arm	25.91	25.88	28.42	20.24	29.69
Lower arm	21.04	20	20	25	18.75
Wrist	51.52	42.35	53.68	76.19	28.13
Finger	31.71	16.47	55.79	32.14	15.63
Upper back	20.43	12.94	12.63	17.86	45.31
Lower back	50.00	62.35	41.05	55.95	39.06
Knee	22.87	16.47	38.95	15.48	17.19

Table 3. Postural details and corresponding scores (N=154)

Task	REBA		RULA	
	Score (M ± SD)	Severity of risk	Score (M ± SD)	Severity of risk
Spading	11.71 ± 0.80	Very high	6.40 ± 0.64	Very high
Mould filling	11.10 ± 0.82	Very high	6.05 ± 0.76	Very high
Mould evacuating	10.50 ± 0.72	High	5.24 ± 0.74	High
Brick carrying	10.00 ± 0.81	High	5.00 ± 0.85	High

(OR=6.88, 95% CI: 2.40−19.70, p=0.00) regions. Prevalence of MSDs in wrist (OR=12.22, 95% CI: 4.82−30.98, p=0.00), fingers (OR=3.57, 95% CI: 1.23−10.36, p=0.02) and lower back (OR=2.62, 95% CI: 1.14−6.00, p=0.02) were significant in mould evacuating task workers.

Workers having less than five years of experience were less prone to musculoskeletal symptoms in neck (OR=0.03, 95% CI: 0.00–0.72, p=0.03) and upper back (OR=0.08, 95% CI: 0.01−0.76, p=0.03) regions compared to the workers having 10 yr of experience.

Multinomial logistic regression

The multinomial regression analysis was also performed to analyse the association of musculoskeletal symptoms with the risk factors having a significant association in binary logistic regression. The analysis results are shown in Table 6.

The association of workers age with the musculoskeletal issues in all body regions were found comparable with the issues found in binary logistic regression. The spading task was significantly associated with wrist (OR=0.43, 95% CI: 0.20−0.94, p=0.03) and upper back (OR=5.75, 95% CI: 2.51−13.20, p=0.00) symptoms. These results are similar to the results of binary logistic regression. The association of musculoskeletal problems in various body parts with

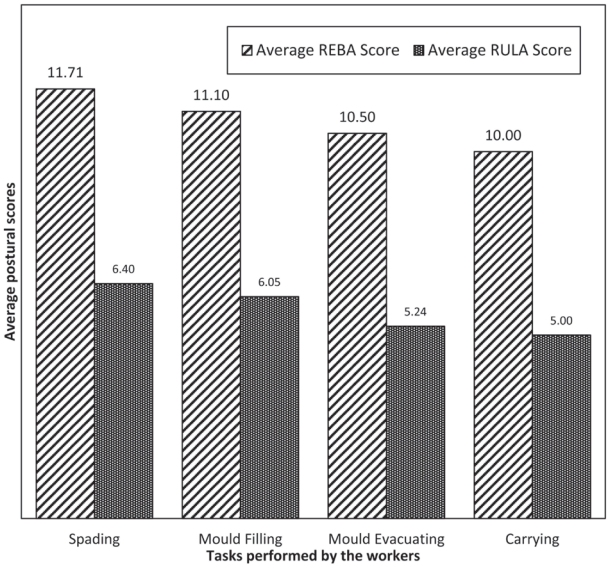

Fig. 3. Postural assessments scores for different tasks.
Interpretation of cores:
REBA score: 1= Negligible risk; 2–3= Low risk; 4–7= Medium risk; 8–10= High risk; 11+= Very high risk.
RULA score: 1–2= Negligible risk: 3–4= Low risk; 5–6= Medium risk; 7= High risk.

Table 4. Association between risk–factors and musculoskeletal issues in neck, shoulder, arm and wrist regions

Factor	Neck (n=62)			Shoulder (n=157)			Upper arm (n=85)			Lower arm (n=69)			Wrist (n=169)		
	χ^2=2.42			χ^2=11.94			χ^2=12.33			χ^2=14.57			χ^2=5.88		
	p	OR	95% CI	*p*	OR	95% CI	p	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI
Age	0.00**	1.19	1.11–1.29	0.00**	1.18	1.11–1.25	0.00**	1.12	1.06–1.19	0.02*	1.06	1.01–1.12	0.02*	1.066	1.01–1.12
Gender[a]															
Male	0.82	0.83	0.18–3.84	0.28	1.64	0.67–3.98	0.60	1.33	0.47–3.77	0.50	1.42	0.51–3.99	0.17	0.53	0.22–1.31
Weight	0.78	1.01	0.92–1.12	0.06	1.07	1.00–1.14	0.16	1.05	0.98–1.13	0.15	0.95	0.88–1.02	0.36	1.03	0.97–1.10
Height	0.14	0.99	0.97–1.00	0.24	0.99	0.99–1.00	0.23	0.99	0.98–1.00	0.91	1.00	0.99–1.01	0.94	1.00	0.99–1.01
BMI[b]															
<18.5	0.08	0.03	0.00–1.59	0.02*	23.37	1.81–301.36	0.42	3.03	0.20–45.21	1.00	82902256.34	0.00	0.58	0.55	0.06–4.63
18.5–24.99	0.21	0.11	0.00–3.47	0.09	7.73	0.75–79.93	0.56	2.06	0.19–22.75	1.00	109320361.57	0.00	0.92	0.91	0.15–5.67
Task[c]															
Spading	0.57	0.72	0.23–2.22	0.17	1.74	0.79–3.85	0.77	1.15	0.46–2.85	0.66	1.24	0.47–3.22	0.04*	2.42	1.03–5.66
Filling	0.13	0.40	0.12–1.30	0.92	0.96	0.43–2.13	0.21	1.79	0.72–4.42	0.44	1.46	0.56–3.81	0.00**	4.27	1.81–10.09
Evacuating	0.00**	0.15	0.04–0.55	0.26	0.62	0.27–1.42	0.34	0.63	0.24–1.63	0.46	1.44	0.55–3.73	0.00**	12.22	4.82–30.98
Experience[d]															
<5 yr	0.03*	0.03	0.00–0.72	1.00	0.00	0.00	0.44	0.40	0.04–4.20	0.07	0.10	0.01–1.19	0.60	0.44	0.02–8.09
5–10 yr	0.68	0.61	0.05–6.73	1.00	0.00	0.00	0.84	1.25	0.15–10.47	0.28	0.28	0.03–2.84	0.80	1.37	0.09–21.60
Smoking															
Smoker[e]	0.62	1.27	0.49–3.28	0.70	1.15	0.58–2.28	0.05	2.19	0.998–4.792	0.80	1.10	0.54–2.26	0.05	0.49	0.240–1.01

n: Number of workers having musculoskeletal issues; CI: Confidence interval; *p*: Significance value.

*Significant at $p<0.05$, **Significant at $p<0.01$.

[a]With reference to female, [b]With reference to BMI 25–29.99, [c]With reference to carrying, [d]With reference to experience >10 yr, [e]With reference to non-smoker.

Table 5. Association between risk–factors and musculoskeletal issues in the finger, back and knee regions

Factor	Finger (n=104)			Upper back (n=67)			Lower back (n=164)			Knee (n=75)		
	χ^2=15.11			χ^2=9.03			χ^2=4.90			χ^2=9.45		
	p	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI
Age	0.03*	1.06	1.01–1.12	0.94	1.00	0.95–1.05	0.04*	1.06	1.00–1.11	0.00**	1.11	1.04–1.17
Gender[a]												
Male	0.01*	0.26	0.09–0.73	0.20	0.49	0.17–1.44	0.00**	3.71	1.51–9.11	0.06	0.34	0.11–1.06
Weight	0.00**	1.15	1.07–1.24	0.63	1.02	0.95–1.10	0.02*	0.92	0.86–0.98	0.09	1.07	0.99–1.16
Height	0.14	0.99	0.980–1.00	0.67	1.00	0.99–1.01	0.92	1.00	0.99–1.01	0.87	1.00	0.99–1.02
BMI[b]												
BMI <18.5	0.83	0.77	0.07–9.08	0.34	0.26	0.02–4.25	0.95	1.09	0.09–14.02	0.67	2.03	0.08–50.54
BMI 18.5–24.99	0.37	0.38	0.04–3.21	0.69	0.60	0.05–7.05	0.79	1.37	0.13–14.11	0.33	4.13	0.24–70.98
Task[c]												
Spading	0.54	1.42	0.46–4.37	0.00**	0.16	0.06–0.40	0.00**	3.97	1.75–8.98	0.96	1.03	0.35–3.04
Filling	0.00**	17.56	5.90–52.31	0.00**	0.14	0.06–0.36	0.17	1.78	0.79–4.00	0.00**	6.88	2.40–19.70
Evacuating	0.02*	3.57	1.23–10.36	0.00**	0.20	0.08–0.48	0.02*	2.62	1.14–6.00	0.43	0.64	0.21–1.94
Experience[d]												
<5 yr	0.09	0.09	0.01–1.49	0.03*	0.08	0.01–0.76	1.00	0.00	0.00	0.06	0.07	0.01–1.13
5–10 yr	0.50	0.47	0.03–5.39	0.17	0.25	0.03–1.86	1.00	0.00	0.00	0.41	0.35	0.03–4.19
Smoking												
Smoker[e]	0.76	0.90	0.44–1.83	0.15	0.58	0.28–1.21	0.66	1.16	0.59–2.31	0.33	1.48	0.67–3.25

n: Number of workers having musculoskeletal issues; CI: Confidence interval; *p*: Significance value.

*Significant at $p<0.05$, **Significant at $p<0.01$.

[a]With reference to female, [b]With reference to BMI 25–29.99, [c]With reference to carrying, [d]With reference to experience >10 yr, [e]With reference to non-smoker.

other risk factors was also found somewhat similar to the results of binary logistic regression.

Discussions

Due to a lot of manual work with traditional methods and long working hours, clay brick manufacturing is a strenuous occupation in India. Findings of the present study showed that most of the labours in this sector belong to the age group of 21–30 yr, which is almost similar to the results of previously published studies[2, 3, 24, 26]. Therefore, it seems that the workers of higher age group find it hard to be in this profession. In contradiction to the previous studies[2, 3, 5], the majority of workers were found with normal BMI. This shows the better nutritional condition of brick workers in Rajasthan in contrast to some other Indian studies[2, 5, 24].

Shoulder related problems among workers doing spading and brick carrying tasks were found to be higher than average in the present study. These numbers are also higher compared to another previously reported work[36] (23.5%) in the same field. Some other Indian researchers[12, 37–38] have reported a larger number of shoulder issues (56.7%, 87. 8% and 84.4%) in similar tasks compared to the present study. It could be the result of repetitive awkward movement (beyond 90°, raised and abducted positions) of shoulders during these activities. Musculoskeletal problems in the wrist regions were very high among workers performing the evacuating task which is also higher than wrist problems reported by Inbaraj *et al*[36]. The probable reason of larger number of wrist issues could be repetitive twisting and bending of the wrist while reversing the moulding box having improperly designed handle size and orientation.

Pain and discomfort in fingers were very high among workers involved in the mould filling task. However, the issues were lower as compared to a previous research by Das[5], which reported finger related issues among 93% brick workers. The reason behind this can be attributed to excessive strain during clot cutting, pulling and mould filling. The occurrence of lower back pain and discomfort was very high within workers performing spading and mould evacuating tasks. Inbaraj *et al.*[36], Das[5] and Das[26] have also reported lower back pain among 59%, 70% and 93% brick workers respectively. Prolonged squatting posture and repetitive bending during these tasks can be the possible causes of lower back issues.

Table 6. Association of musculoskeletal problems in body parts with risk–factors (multinomial logistic regression)

Body part	Factor	*p*	OR	95% CI
Neck	Age	0.00**	0.85	0.80–0.90
	Task (*referent carrying*)			
	Mould Filling	0.03*	3.20	1.09–9.40
	Mould evacuating	0.00**	7.82	2.50–24.68
	Experience (*referent >10 yr*)			
	<5 yr	0.03*	35.78	1.43–893.02
Shoulder	Age	0.00**	0.86	0.83–0.90
Upper arm	Age	0.00**	0.88	0.85–0.91
Lower arm	Age	0.00**	0.91	0.88–0.94
Wrist	Age	0.00**	0.88	0.84–0.91
	Task (*referent carrying*)			
	Spading	0.03*	0.43	0.20–0.94
	Mould filling	0.00**	0.22	0.10–0.48
	Mould evacuating	0.00**	0.08	0.04–0.19
Fingers	Age	0.00**	0.88	0.86–0.92
	Weight	0.00**	0.90	0.85–0.96
	Task (*referent carrying*)			
	Mould filling	0.00**	0.09	0.04–0.22
	Mould evacuating	0.03*	0.36	0.14–0.92
	Gender (*referent female*)			
	Male	0.02*	2.88	1.17–7.07
Upper back	Task (*referent carrying*)			
	Spading	0.00**	5.75	2.51–13.20
	Mould filling	0.00**	5.77	2.55–13.04
	Mould evacuating	0.00**	4.42	2.02–9.68
	Experience (*referent >10 yr*)			
	<5 yr	0.01*	14.35	2.05 –100.26
Lower back	Age	0.00**	0.89	0.86–0.92
	Weight	0.00**	1.09	1.03–1.16
	Task (*referent carrying*)			
	Spading	0.00**	0.28	0.13–0.59
	Mould evacuating	0.01*	0.39	0.18–0.81
	Gender (*referent female*)			
	Male	0.00**	0.20	0.09–0.46
Knee	Age	0.00**	0.86	0.82–0.89
	Task (*referent carrying*)			
	Mould filling	0.00**	0.17	0.07–0.44

The reference response is 1.

*Significant at $p<0.05$, **Significant at $p<0.01$.

The postural analysis gave very high values of both REBA and RULA scores for spading and mould filling tasks. The use of un-ergonomically designed traditional hand tools with awkward postures and lack of awareness of ergonomic principles might be the probable reasons behind high postural risks[12]. Studies related to postural analysis in brick kiln industry are limited. However, similar results were obtained in previous studies conducted on Indian manual farming sector[34, 35] where the spading task and squatting postures adopted while working are similar to those in the brick industry.

Results of logistic regressions showed that workers' age was significantly associated with musculoskeletal symptoms in most of the body parts. This is understandable and is also in line with some of the other Indian studies[5, 34, 36]. Type of task was also found to be an important contributing factor in causing discomfort in different body regions. Prevalence of lower back issues in males was higher as compared to

females which can be attributed to work-related factors, and physiological and anatomical differences between males and females[39]. Underweight workers were more prone to shoulder related MSDs which seems apparent as these workers have comparatively lesser strength[2, 40].

To extend the findings of present research work, further study using advanced techniques like electromyography (EMG) may be conducted to identify long-term biomechanical and physiological changes among brick kiln workers. Psychological and other socio-economic factors may be considered in future work. The present study focussed on workers performing specific tasks (i.e., spading, mould filling, evacuating and carrying) in the last six months. This study can be extended future by including the effects of job rotation on musculoskeletal symptoms. The present study was limited to the Rajasthan state of India only, other regions can be included in future studies.

Recommendations

To improve the musculoskeletal health of kiln workers, the following measures are proposed:

• Workers should be trained in occupational safety and ergonomic principles. They should be encouraged to use personal protection aids like the lumbar belt to reduce lower back issues.

• The duration of rest should be split into short breaks, and workers should be motivated to change their postures periodically with various stretching practices to relieve excessive muscular stress.

• Tasks should be rotated between males and females, among age groups and BMI categories periodically as these factors are associated with musculoskeletal issues.

• Use of trolleys should be motivated not only in brick carrying but also in mould carrying.

• Moulding box and other hand tools should be redesigned ergonomically, and the use of already redesigned hand tools (i.e., spade, trowel, etc.) must be promoted to reduce wrist and finger issues[11, 22].

Conclusions

From the outcomes of the present study, it was concluded that clay brick manufacturing in traditional kilns is a high-risk occupation, and causes MSDs among workers. Workers prefer this occupation in their young age only and migrate to other sectors due to various issues. The investigation showed that most of the brick kiln workers suffered from musculoskeletal problems in the wrist, lower back, shoulder, finger, upper arm and knee regions due to prolonged working in a specific task with a load, repetition and awkward postures (i.e., twisting, flexion, bending, abduction, kneeling, squatting, etc.).

Postural analysis showed that kiln workers are exposed to very high risks in spading and mould filling tasks. The risk levels were found high in mould evacuating and carrying tasks too. Outcomes of binary logistic regression proved that personal (i.e. age, gender, BMI) and occupational factors (i.e., experience, task type) affect the prevalence of MSDs in one or more body parts among the workers. The association between risk factors and 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.

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