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ASSESSMENT OF OCCUPATIONAL HEALTH PROBLEMS AND PHYSIOLOGICAL STRESS AMONG THE BRICK FIELD WORKERS OF WEST BENGAL, INDIA

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Abstract
Objectives: The brick field industry is one of the oldest industries in India, which employs a large number of workers of poor socioeconomic status. The main aim of the present investigation is i) to determine the prevalence of musculoskeletal disorders among brick field workers, ii) to determine the prevalence of respiratory disorders and physiological stress among brick field workers compared to control workers. **Material and Methods:** For this study, a total of 220 brick field workers and 130 control subjects were selected randomly. The control subjects were mainly involved in hand-intensive jobs. The Modified Nordic Questionnaire was applied to assess the discomfort felt among both groups of workers. Thermal stress was also assessed by measuring the WBGT index. The pulmonary functions were checked using the spirometry. Physiological assessment of the workload was carried out by recording the heart rate and blood pressure of the workers prior to work and just after work in the field. **Results:** Brick field workers suffered from pain especially in the lower back (98%), hands (93%), knees (86%), wrists (85%), shoulders (76%) and neck (65%). Among the brick-making activities, brick field workers felt discomfort during spading for mud collection (98%), carrying bricks (95%) and molding (87%). The results showed a significantly lower p value < 0.001 in FVC, FEV_1, FEV_1/FVC ratio and PEFR in brick field workers compared to the control group. The post-activity heart rate of the brick field workers was 148.6 beats/min, whereas the systolic and diastolic blood pressure results were 152.8 and 78.5 mm/Hg, respectively. **Conclusions:** This study concludes that health of the brick field workers was highly affected due to working in unhealthy working conditions for a long period of time.

Key words:
Brick field workers, Physiological stress, Occupational health problems, Thermal stress, Lung function values, Hand-grip strength

INTRODUCTION

In India, occupational health problems are gaining momentum. Assessment of occupational health problems is one of the common fields of study of ergonomics. The brick field industry is one of the oldest industries in West Bengal, India. It involves a large number of workers of poor socio-economic status. Brick field workers generally perform rigorous hand-intensive jobs for a sustained period of time and are forced to carry various amounts of load during their work, due to which they may suffer from musculoskeletal disorders (MSDs) and other occupational health problems. Musculoskeletal disorders (MSDs) can be caused by heavy physical work, static work postures, frequent bending and twisting, lifting, pushing and pulling, repetitive work, vibration and psychological and psychosocial stress [1]. In the brick field industry, the workers perform heavy manual tasks in

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a repetitive manner for a prolonged period of time, which may lead to severe physical stress among them. Das [2] stated that the brick field workers found discomfort in different parts of the body due to working in an awkward posture for a long time. According to Burdorf and Sorock [3], manual material handling, awkward back postures and heavy physical work are work-related physical risk factors for low back pain.

Brick field workers perform several types of strenuous activity, such as: i) cutting the mud with a spade, ii) carrying the mud, iii) preparation of clay, iv) carrying the clay, v) molding, vi) stacking (loading and unloading the bricks), vii) carrying the bricks (green & burn bricks), and viii) burning the bricks in kiln. During this process, brick field workers have to face a lot of problems. For instance, molders are directly exposed to dust which contains a mixture of inorganic compounds including free silica, iron oxide, etc. On the other hand, brick kiln workers (firemen) have to face very high temperature along with more proximal exposure to smoke and some toxic gases like sulfur dioxide, hydrogen sulfide, carbon dioxide and carbon monoxide, as well as particulate air pollutants while burning biomass fuels [4]. Adverse environmental and physical conditions affect the health status of brick field workers who perform also other types of activities, e.g. they have to walk on a hot surface (top of the furnace) while monitoring and regulating the fire. Physiological responses to such activities mainly involve the musculoskeletal and cardiovascular systems. Since the environment is unfriendly, it hinders excess heat elimination by the circulatory system, making the heart work harder to transport energy to the muscles for a successful completion of the job. An increase in age concurrently deteriorates the functional capacity [5].

OBJECTIVES

The main aim of the present investigation was i) to determine the prevalence of musculoskeletal disorders (MSDs) among brick field workers compared to control workers of the West Bengal, ii) to determine the prevalence of respiratory disorders among brick field workers exposed to dusts in the brick fields compared to the control workers, iii) to analyze thermal stress, iv) to assess physiological stress, and v) to identify unfavorable work conditions among the brick field workers.

MATERIAL AND METHODS

Selection of subjects and working sites

A cross-sectional study was conducted on 220 male brick field workers from 12 brick fields, working in a selected brick field unit of Bhadrakali in Hooghly district, which was situated at the side of the Hooghly River, 130 male control group subjects also selected randomly, who were engaged in office work involving minimum amount of hand-intensive job. The brick field unit was selected randomly from the surrounding area. The inclusion criteria of the selection of the subjects for both groups were: age 18–58 years, experience in different brick field activities or office activities for 1 year. The study was conducted from March 2012 to April 2013 at 20 brick fields. Our study participants (220 male brick field workers) were randomly selected from 752 brick field workers of 20 brick fields of Bhadrakali, Uttarpara and Kotrung area in Hooghly district, India.

The selected 220 male brick field workers generally perform different types of manual work in an awkward posture, which may cause the physical and biomechanical load. They carry huge weight of mud, raw brick and burn bricks on their heads, which affects their health. The 130 male control subjects are generally office workers responsible for the arrangement of files, distribution of documents in different sections of the office and serving tea, water and food to staff members on request. Among the 220 male brick field workers, 182 were smokers and 38 were non-smokers, whereas in case of 130 control subjects, 77 were smokers and 53 were non-smokers.

Most smokers among male brick field workers smoked on average 11 beedi (small local type of cigar) per day, whereas smokers among the control subjects smoked on average 7 beedi/day.

Measurement of physical parameters

The height and weight of the brick field workers were measured by an anthropometer and a weighing machine, respectively. The body mass index (BMI) [6] of all the subjects was also computed. Before the survey, consent was taken from brick field owners as well as each individual subject. Written permission for the project was obtained from the Institutional Human Ethical Clearance Committee of the Indian Council of Medical Research Guidelines.

Questionnaire study

A detailed modified Nordic musculoskeletal disorder questionnaire [7] was developed and applied to the brick field workers as well as the controls. A questionnaire based on the modified Nordic musculoskeletal disorder questionnaire was completed by both groups. The questionnaire consisted of a number of objective questions, with multiple choice answers identifying the participant's personal viewpoints, pattern of work, duration of work, and discomfort levels in different parts of the body.

Measurement of hand-grip strength

A physical examination was performed by hand-grip dynamometer to measure the hand-grip strength of the brick field workers and compare the results with the control group. The brick field workers and the control subjects were asked to adopt an upright standing position without side bending, with arms at their side, not touching their body. The dynamometer should be gripped with full force [8]. The measurement was done twice in a day, prior to brick-making activities and just after their completion at 90° elbow flexion and 180° elbow flexion, as it has been observed that the highest and the lowest value of grip strength vary in accordance with the elbow position [9].

Pulmonary Function Test (PFT)

The examinations were performed with the use of a Spirometer (RMS HELIOS 401). Three successive recordings of forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1) and forced expiratory ratio (FEV_1/FVC ratio) were performed in the standing position and the best of the 3 ratings was recorded.

Peak expiratory flow rate (PEFR) is the maximum flow rate generated during a forceful exhalation, starting from full lung inflation. It measures the airflow through the bronchi and thus the degree of obstruction in the airways. The measurement of the peak expiratory flow rate (PEFR) was done with a mini Wright's peak flow meter (Clement Clarke International, UK). Prior to recording the subjects' peak expiratory flow rate (PEFR), the use of the instrument was repeatedly demonstrated and explained to them. The peak expiratory flow rate (PEFR) test was performed in the standing position with the peak flow meter held horizontally. The subjects were asked to take as deep a breath as possible and then to blow out as hard and as quickly as possible. The best of the 3 ratings was recorded.

Assessment of thermal stress

The working environment of the brick field workers was assessed as follows. The wet bulb globe temperature (WBGT) index was calculated [10]. The mean globe temperature and wet and dry bulb temperatures were recorded. The formula for calculating the WBGT index for outdoor conditions is:

$$\text{WBGT (outdoor)} = 0.7\,(\text{NWB}) + 0.2\,(\text{GT}) + 0.1\,(\text{DB}) \quad (1)$$

where:
NWB – the natural wet bulb temperature,
DB – the dry bulb temperature,
GT – the globe temperature.

Relative humidity was also estimated with a psychometric chart developed by Weksler Instrument (USA) [11].

Assessment of physiological parameters

Physiological stress assessment was carried out by recording the heart rate of the brick field workers prior to work and just after completion of work. The resting or prior-to-work heart rate was measured from the radial pulse for 1 min with the help of a stopwatch and the heart rate just after work was recorded from the carotid pulse with the 10 beats method [12]. The blood pressure of the brick field workers was measured with a sphygmomanometer and a stethoscope before and just after completion of work. Blood pressure measurements were made in 2 phases, one in a resting condition and the other just after completion of work among 2 groups of workers. Left arm blood pressure was taken with a sphygmomanometer and a stethoscope after the participant had been seated in a relaxed position for 5 min in a resting position. In case of the 2nd measurement, left arm blood pressure was taken with a sphygmomanometer and a stethoscope after the participant had been seated immediately after work. Systolic (SBP) and diastolic (DBP) blood pressures were recorded to the nearest mm Hg as the appearance (phase I) and disappearance (phase V) of Korotkoff sounds, respectively.

Maximum heart rate (HRmax) was estimated from age following the equation of the American heart association [13]. Heart rate reserve (HRR) was calculated as the difference between the maximal and resting heart rate of the subjects. Net cardiac cost (NCC) was obtained as the difference between WHR (working heart rate) and resting heart rate, expressed as beats/min. Relative cardiac cost (RCC) was determined by expressing the NCC as the percentage of the heart rate reserve (HRR) of the subjects by using the following formula:

$$RCC = NCC/HRR \times 100 \quad (2)$$

Data analysis

Data were examined using the statistical package Primer of Biostatistics version 5.0 (Msi Version = 1.20.1827.0, Primer for Windows, Mc-Graw-Hill). Statistical analysis included calculation of the mean and standard deviation of the various physical parameters. In this study, normal samples were drawn from the normal population, so the Student's t-test was performed to find out whether there was any significant difference between the demographics of the brick field workers and the control group.

Comparisons of the means of different physiological parameters of the brick field workers and the control subjects were also made with the Student's t-test. A 2-tail Chi^2 test of independence was applied to determine whether or not the test item had any significant association with discomfort. The computed Chi^2 was next compared with the critical Chi^2 values for the chosen level of significance (p value). One-way Anova test was also used to determine whether there was any significant difference between the hand-grip strength values of the brick field workers and the control subjects for the chosen level of significance ($p < 0.001$)

RESULTS

The mean values of age, height, weight, BMI and average years of working experience in both groups (brick field workers and control subjects) are shown in Table 1. The average duration of work among the brick field workers was 9.2 h/day (SD = 1.2), and among the control subjects – 7.1 h/day (SD = 1.3).

The analysis of the modified Nordic questionnaire presented in Table 2 showed that most brick field workers reported discomfort in different body parts. Most brick field workers felt discomfort mainly in the lower back (98%), hands (93%), knees (86%), wrists (83%) and shoulders (76%), respectively. These results also showed that a large proportion of these problems lasted for more

Table 1. Characteristics of the brick field workers and the control group

Variable	Brick field workers (N = 220)	Control group (N = 130)	t	p
Age (years) (M±SD)	33.5±6.2	34.2±6.7	0.99	0.323
Height (cm) (M±SD)	169.2±4.1	169.9±4.6	1.47	0.141
Weight (kg) (M±SD)	55.2±6.2	58.5±5.8	4.92	< 0.001
Body mass index (M±SD)	18.8±1.8	19.6±1.7	4.10	< 0.001
Seniority (years) (M±SD)	14.2±4.8	10.5±3.2	7.82	< 0.001
Average duration of work per day (h) (M±SD)	9.2±1.2	7.0±1.3	16.00	< 0.001
Working days in a week (n)	7	7	–	–

M – mean; SD – standard deviation.
t – Student's t-test value.

Table 2. Feeling of discomfort in different parts of the body among the brick field workers and in the control group

Part of the body	Brick field workers (N = 220) [n (%)]	Control group (N = 130) [n (%)]	Chi^2	p
Neck	142 (65)	3 (2.0)	127.00	< 0.001
Shoulders	167 (76)	5 (4.0)	166.90	< 0.001
Elbows	91 (41)	0 (0.0)	70.50	< 0.001
Wrists	188 (85)	4 (3.0)	220.60	< 0.001
Hands	204 (93)	8 (6.0)	252.80	< 0.001
Upper back	33 (15)	0 (0.0)	19.80	< 0.001
Lower back	216 (98)	28 (22.0)	195.90	< 0.001
Knees	190 (86)	26 (20.0)	149.50	< 0.001
Ankles	11 (5)	2 (1.5)	1.85	0.173
Feet	32 (15)	1 (1.0)	16.58	< 0.001

than 1 year, with many brick field workers experiencing prolonged discomfort (pain) for more than 5 years. However, the majority of those with a discomfort feeling were still able to continue their work. The control subjects suffered from pain especially in the lower back (22%) and knees (20%), and the pain in other parts of the body was negligible.

Table 3 shows the feeling of discomfort in the brick field workers engaged in various activities in the brick field. Most of them reported discomfort during spading for mud collection (98%), followed by carrying bricks (95%), molding (87%), loading and unloading bricks (84%), setting bricks in the kiln (81%), etc.

From Table 4 it was observed that there was a significant difference ($p < 0.05$) in hand-grip strength measured at 90° elbow flexion and 180° elbow flexion just after stoppage of work between the brick field workers and the control subjects. In the resting condition, the

Table 3. Feelings of discomfort (pain) during different activities in brick-making

Activity in the brick-making process	Brick field workers (N = 220)	
	participants affected (n)	feeling of discomfort (%)
Spading for mud collection	215	98
Loading mud	166	75
Carrying mud	155	70
Preparation of clay	18	8
Carrying clay	28	13
Molding	192	87
Stacking	116	53
Setting bricks in the kiln	178	81
Loading and unloading bricks	185	84
Carrying bricks	210	95

Table 4. Relationship between the hand-grip strength in the brick field workers and in the control group

Hand-grip strength	Condition	Brick field workers (N = 220) (M±SD)	Control group (N = 130) (M±SD)	F	p
At 90° elbow flexion (kg)	resting condition	41.20±4.28	40.98±3.32	0.25	0.615
	just after stoppage of work	35.88±2.28	37.25±2.36	28.74	< 0.001
At 180° elbow flexion (kg)	resting condition	41.20±4.28	40.98±3.32	0.25	0.615
	just after stoppage of work	34.92±2.23	36.88±2.68	54.20	< 0.001

F – F distribution under null hypothesis. Other abbreviations as in Table 1.

brick field workers had higher hand-grip strength than the control subjects, but soon after completion of work there was a marked decrease in the hand-grip strength among the brick field workers compared to the control subjects.

Table 5 presents the thermal stress associated with different brick-making activities. It was noted that the brick field workers suffered from heavy thermal stress during the last stages of brick-making. Setting the bricks in kiln and loading the burn bricks from the kiln are the main activities that are carried out at temperatures exceeding 32°C with an 80–90% relative humidity.

Table 6 shows the comparison of the lung function parameters between brick field workers and the control subjects. There was a significant difference in spirometry findings (FVC, FEV_1, FEV_1/FVC ratio, PEFR) between brick field workers and the control subjects. It can be said that the changes in pulmonary variables in brick field workers in comparison to the control subjects were due to the constant exposure to unhealthy working conditions, which deteriorated the pulmonary health condition of the brick field workers.

Table 7 shows the pulmonary function test among smokers and non-smokers, in which the significant change was observed in case of FVC (l), FEV_1 (l) and PEFR (l/min)

Table 5. Average temperatures during different activities (outdoor WBGT index of the workshops) in the brick-making process

Activity during brick-making	Thermometer	Average temperature (°C)	WBGT index (°C)	Relative humidity (%)
Spading for mud collection	globe	36.2	25.6	78
	wet bulb	22.4		
	dry bulb	26.1		
Loading mud	globe	36.2	25.6	78
	wet bulb	22.4		
	dry bulb	26.1		
Carrying mud	globe	36.2	25.6	78
	wet bulb	22.4		
	dry bulb	26.1		
Preparation of clay	globe	37.4	26.3	82
	wet bulb	23.1		
	dry bulb	26.3		
Carrying clay	globe	37.4	26.3	82
	wet bulb	23.1		
	dry bulb	26.3		
Molding	globe	37.4	26.3	82
	wet bulb	23.1		
	dry bulb	26.3		
Stacking bricks	globe	35.3	26.7	84
	wet bulb	24.2		
	dry bulb	26.8		
Setting bricks in the kiln	globe	37.5	33.2	82
	wet bulb	31.7		
	dry bulb	34.8		
Loading and unloading bricks	globe	35.3	32.0	89
	wet bulb	30.9		
	dry bulb	32.7		
Carrying bricks	globe	35.3	32.0	89
	wet bulb	30.9		
	dry bulb	32.7		

WBGT – wet bulb globe temperature.

Table 6. Lung function test parameters in the brick field workers and in the control group

Parameter	Brick field workers (N = 220) (M±SD)	Control group (N = 130) (M±SD)	t	p
FVC (l)	3.38±0.12	4.16±0.15	53.40	< 0.001
FEV_1 (l)	2.58±0.15	3.58±0.18	55.90	< 0.001
FEV_1/FVC (%)	76.33±3.24	86.05±1.93	31.10	< 0.001
PEFR (l/min)	412.20±48.72	472.50±41.74	11.78	< 0.001

FVC – forced vital capacity; FEV_1 – forced expiratory volume in 1 s; FEV_1/FVC – forced expiratory ratio; PEFR – peak expiratory flow rate. Other abbreviations as in Table 1.

Table 7. Pulmonary function test results of smokers and non-smokers (brick field workers and the control group)

Parameter	Brick field workers (M±SD)		t	p	Control group (M±SD)		t	p
	smokers (N = 182)	non-smokers (N = 38)			smokers (N = 77)	non-smokers (N = 53)		
FVC (l)	3.18±0.14	3.77±0.13	23.90	< 0.001	4.12±0.14	4.22±0.16	3.770	< 0.001
FEV_1 (l)	2.47±0.13	2.88±0.16	16.90	< 0.001	3.54±0.16	3.64±0.19	3.240	0.002
FEV_1/FVC (%)	77.67±3.22	76.39±3.28	2.22	0.027	85.92±1.88	86.25±1.98	0.962	0.338
PEFR (l/min)	408.20±46.21	426.80±49.28	2.23	0.027	459.80±40.24	490.50±43.21	4.140	< 0.001

Abbreviations as in Table 1 and 6.

among the smokers and non-smokers in the examined groups.

The heart rates of the brick field workers are given in Table 8. It was found that the heart rate rose to more than 100 beats per min during almost all the activities (except preparation of clay). It was also observed that the heart rate was highest during spading (148 beats/min) for mud collection, showing that it is the most strenuous of all the tasks. Table 9 presents physiological stress of the brick field workers and the control subjects. The resting heart rate and blood pressure (systolic and diastolic) of both groups did not show any significant change; whereas, just after work, the heart rate and blood pressure (systolic and diastolic) of both the brick field workers and the control subjects showed a significant change.

Table 8. Comparative physiological stress (heart rate) in the brick field workers and in the control group

Activity in the brick field	Heart rate (beats/min) (M±SD)		t	p
	brick field workers (N = 220)	control group (N = 130)		
Resting	88.2±4.4	87.5±3.8	1.51	0.132
Spading for mud collection	148.6±5.3	96.8±4.9 (just after work)	90.80	< 0.001

Table 8. Comparative physiological stress (heart rate) in the brick field workers and in the control group – cont.

Activity in the brick field	Heart rate (beats/min) (M±SD) brick field workers (N = 220)	Heart rate (beats/min) (M±SD) control group (N = 130)	t	p
Loading mud	128.1±3.2		72.20	< 0.001
Carrying mud	137.1±4.8		75.30	< 0.001
Preparation of clay	94.2±3.7		5.61	< 0.001
Carrying clay	106.2±5.1		16.90	< 0.001
Molding	100.3±4.2		7.07	< 0.001
Stacking bricks	102.5±5.5		9.74	< 0.001
Setting bricks in the kiln	108.2±6.2		17.90	< 0.001
Loading and unloading bricks	110.5±5.8		22.60	< 0.001
Carrying bricks	132.8±6.3		55.90	< 0.001

Abbreviations as in Table 1.

Table 9. Physiological and physical workload in the brick field workers and in the control group

Physiological parameter	Brick field workers (N = 220) (M±SD)	Control group (N = 130) (M±SD)	t	p
Heart rate (beats/min)				
resting	88.2±4.4	88.5±3.8	0.648	0.518
just after work	148.6±5.3	96.8±4.9	90.820	< 0.001
Blood pressure systolic (mm Hg)				
resting	112.2±5.6	116.7±5.3	7.400	< 0.001
just after work	152.8±3.9	120.8±4.1	72.760	< 0.001
Diastolic (mm Hg)				
resting	78.5±4.7	80.8±4.8	4.380	< 0.001
just after work	88.2±5.3	82.0±5.5	10.420	< 0.001
HRmax	186.5±5.6	185.8±5.1	1.160	0.244
HRR	98.3±4.9	97.3±4.3	1.920	0.055
NCC	60.4±4.2	8.3±5.1	103.400	< 0.001
RCC	61.4±4.6	8.53±4.0	108.930	< 0.001

HRmax – maximum heart rate; HRR – heart rate reserve; NCC – net cardiac cost; RCC – relative cardiac cost.
Other abbreviations as in Table 1.

DISCUSSION

The prevalence of occupational health hazards has been reported as high among people of India [14]. The results of the study also revealed that the brick field workers (an experimental group) were engaged in rigorous hand-intensive jobs for many years, whereas the control group was not involved in such type of work.

It was also found that brick field workers suffered from discomfort in different parts of the body, especially in the lower back, knees and upper extremities. The study mainly shows that the physical as well as biomechanical load of the brick field workers is high in comparison to the control group of workers due to carrying heavy loads in an awkward posture for prolonged period of time.

As demonstrated by Das [2], the postures adopted by the brick field workers during work were characterized by high risk and needed correction immediately. Das [2] and Mukhopadhyay [15] stated that musculoskeletal disorders were observed among the brick field workers due to carrying heavy loads (manual material handling) for a long period of time. This study also revealed that brick field workers felt discomfort in their knees due to kneeling for a prolonged period of time during molding, during loading and unloading the mud and bricks, and while setting the green bricks in the kiln. Jensen et al. support this result [16]. According to them, the prevalence of knee disorders in some occupations was possibly related to kneeling working postures.

This study also indicates clearly that brick carriers mainly carry the bricks on their head. They take 8–10 bricks at a time with approximate total weight of 25–30 kg (1 brick = 4.5–5 kg), which ultimately leads to head, neck and shoulder pain among them. This result was supported by Sahu et al. [17]. According to them, head is the most affected part among the brick carriers. They also added that female brick carriers carry 50 kg and above of load on their head, which exceeds the recommended weight limit (RWL) for Indian adult women. Manual material handling is the cheapest solution in developing countries [18]. Therefore, most of the brick carriers mainly perform such handling. To avoid musculoskeletal disorders, this study suggests decreasing the physical load of the workers and carrying the bricks and mud in the trolley. The results of the study also showed that the brick field workers perform mainly 2 types of hard jobs: brick molding (manufacturing) and carrying. Brick manufacturing workers and brick carriers are engaged in rigorous hand-intensive jobs in a repetitive manner. According to them, spading for the collection of mud for brick-making is an extremely demanding process in which the subjects felt discomfort. This clearly establishes the fact that the feeling of discomfort associated with spading can be attributed to a number of factors. Thus, highly forceful work may be regarded as a causative factor for the development of musculoskeletal disorders in the upper limbs among brick field workers.

Hand-grip strength of both groups was measured at 90° and 180° elbow flexion during rest and just after work. There was a significant difference in the hand-grip strength just after work between the brick field workers and the control group. If brick field workers are constantly engaged in hand-intensive jobs, they may be affected by discomfort (pain) in the upper extremities and significant changes in the hand-grip strength [19]. This result also corroborates with the work of Das et al. [20] and Alperovitch-Najenson et al. [21] who suggest that workers, constantly engaged in hand-intensive jobs, are likely to suffer from upper limbs MSDs. Our results revealed that the decreased hand-grip strength may be related to increased loading at the proximal end, that is, muscles at the cervical spine and shoulder joints may have to exert greater forces in order to control the arm movements.

Occupational risk factors are one of the major causes of respiratory illnesses and symptoms. This study shows that the FVC, FEV_1, FEV_1/FVC ratio and PEFR values are much lower among the brick field workers, due to inhalation of dust particles in the brick fields, compared to the control group. According to Das et al. [22] and Shaikh et al. [4], brick field workers often face several health hazards while performing occupational activities and their PEFR values are much lower than in the control group of workers.

Most brick field workers reported physiological stress during different activities in the process of brick-making. The heart rate is the best indicator of the physiological parameters. The fact that the heart rate of the brick carriers measured just after completion of work was very high may be due to constant movement of the body. Moreover, when a brick carrier bends forward to collect the bricks, the muscles of the abdomen contract and the muscles of the back are stretched. This contracting and stretching of the muscles requires energy. Thus, the heart rates are increased.

According to Mukhopadhyay [15], the relative duration of working in the sun was critical in his subjects and this was substantiated by the elevated physiological parameters well above the normal resting value. Guyton [23] supported the results of this study stating that stretching the muscles causes muscle vasoconstriction, which results in restricted blood flow and increased systolic blood pressure.

This study revealed that there was a significant change in the diastolic blood pressure due to the erect and rigid posture among the brick field workers. Guyton [23] also found that diastolic blood pressure increased during certain activities when the posture was erect and rigid. Moreover, blood pooling in any part of the body causes muscle vasodilatation and an increase in the diastolic blood pressure.

Limitation of study

This study had some limitations. A retrospective study is needed to identify the long-term biomechanical and physiological stress among the brick field workers. There are also other factors that have not been investigated, such as repetition of the work in a sequential posture, an analysis of accidents and psychological factors of the brick field workers and an EMG study of the brick field workers in whom muscle fatigue during work can be assessed.

Recommendation

1. The work schedule should be changed by increasing the number of short rest breaks to avoid excessive physical stress.
2. Different types of stretching exercises should be practiced during the breaks.
3. Job rotation among the brick field workers should also be considered.
4. Masks should be used especially during molding to avoid the inhalation of dust particles.
5. The brick field workers should frequently change their posture to avoid discomfort.
6. The brick carriers should carry the bricks in the trolley, and not in the upper extremities.
7. Smokers of both groups should reduce their smoking habits, otherwise the physiological parameters (blood pressure, hypertension, condition of lungs, heart rate) will seriously affect their health condition.

CONCLUSIONS

The conclusions reached from the investigation are as follows:

1. This study mainly shows that brick field workers are suffering from musculoskeletal disorders (MSDs) especially in the upper extremities of the body, lower back and knees due to working in a kneeling posture and an awkward (stooping, squatting and twisting) posture for a long period of time.
2. This study indicates that brick field workers have lower hand-grip strength due to performing more strenuous hand-intensive jobs than the control subjects.

3. The FEV_1, FEV_1/FVC ratio and PEFR values of the brick field workers are much lower than those in the control subjects due to inhalation of dust particles in the brick fields.
4. Brick field workers suffer from thermal stress during the last part of brick manufacturing, which affects their health.
5. Brick field workers suffer from severe physiological stress due to hazardous working conditions and work behavior. Increased heart rates and blood pressure also affect their health and the overall work performance.

Future research

The future research needs have been identified as follows:
1. The nutritional status of the brick field workers should be obtained by a diet survey.
2. Known co-morbidities that contribute to musculoskeletal disorders (such as diabetes, hypertension, thyroid disease, pregnancy, etc.) should be studied.

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