Int Health 2019; **11**: 250–257
doi:10.1093/inthealth/ihy071 Advance Access publication 17 October 2018

ORIGINAL ARTICLE

Health hazards and risks for musculoskeletal problems among child labourers in the brickfield sector of West Bengal, India

Banibrata Das*

Department of Physiology, South Calcutta Girls' College, University of Calcutta, Kolkata 700025, India

*Corresponding author: 100 Biplabi Ganesh Ghosh Sarani, Post-Bhadrakali, Dist Hooghly, Pin code-712232, West Bengal, India. Tel: +919433895285; +918961568057; +913326640388; Fax: +913324542265; E-mail: dr.banibrata@gmail.com; dr.banibrata@yahoo.com

Received 9 May 2018; revised 17 August 2018; editorial decision 21 August 2018; accepted 21 August 2018

Aims: The purpose of this study was to describe the health hazards among child labourers in brickfields, and to assess occupational health problems, together with physiological and respiratory stress, compared with child control subjects.

Methods: A cross-sectional study was conducted on 112 child brickfield workers and 120 control subjects, and a modified Nordic Questionnaire was applied to assess the discomfort felt among both groups of workers. Physiological assessment of the workload was carried out by the measurement of heart rate, blood pressure and spirometry of the workers.

Results: Child brickfield workers suffer from pain, especially in the lower back (97%), shoulder (88%), hands (82%), wrist (76%), neck (73%) and ankle (71%). The post-activity heart rate of the child brickfield workers was 166.5 beats/min, whereas the systolic and diastolic blood pressures were 132.2 and 67.2 mm/Hg, respectively. The forced vital capacity value of child brickfield workers was 2.04, and in the case of the controls it was 2.18, which was significantly different. The forced expiratory volumes in 1 s of experimental and control subjects were 1.82 and 1.92, respectively. The peak expiratory flow rate was significantly different between the two groups.

Conclusions: Most of the brick-making activities were strenuous ones that affected the children. The cardiovascular and respiratory health of the child brickfield workers has changed markedly due to strenuous activity. The child brickfield workers also experienced other occupational health problems and severe musculoskeletal pain.

Keywords: Child labour, hand-grip strength, musculoskeletal pain, physiological stress, pulmonary function test, thermal stress

Introduction

India has the largest number of urban and rural child workers in the world. The Government of India acknowledges that there are at least 17.5 million working children.[1] Child labour refers to all forms of work undertaken by children below 18 years of age. Child labour is an economic and social issue in developing countries because children are perceived to represent an important source of family total income. Poverty has a strong, direct and bilateral link to children's schooling. Due to lack of money, most of the parents did not send their children to school. Lack of money to pay school costs and school-related expenses can be a factor in engaging in child labour among children, in an attempt to earn some money to contribute to their family's expenses. In addition, a family environment can also be a factor that encourages or discourages children to work outside their home. Some families may be violent and thus unable to provide a safe and protective environment for children. Other families may be addicted to gambling and alcohol. In such cases, children can be forced to work, either voluntarily, just to avoid the unpleasant home environment, or involuntarily, to earn money for the family. Another reason is the cheap labour of children. Cheap child labour in the labour market contributes to the growing number of child workers and child exploitation in various sectors of the economy.[2]

Brick-making work is mainly considered to be a highly physically demanding occupation.[3] In the manual brick-manufacturing industry, child workers have to perform various types of hard and strenuous work that leads to work-related musculoskeletal disorders (MSDs) in different parts of the body in the near future. Working with a heavy load in an awkward posture for long durations leads to musculoskeletal problems and different

occupational health problems among child brickfield workers.[4] Child workers in brick factories usually performed multiple tasks. Common tasks are pushing wheelbarrows, loading bricks in and out of the kiln, loading bricks onto and out of brick wheelbarrows, loading bricks, moulding bricks, stacking bricks, carrying bricks and arranging bricks to dry. The tasks performed by child brickfield workers are described next.

Different tasks in a brickfield

- *Pushing wheelbarrows*: children generally push the wheelbarrow to carry mud for moulding.
- *Loading bricks*: children are also involved in loading and unloading bricks in the kiln, as well as into the storage area, together with their guardians and parents.
- *Moulding*: children are engaged in moulding the bricks, generally helping their parents with this work; they also do the same work as a cheap labourer.
- *Carrying bricks*: children usually perform this job with the help of wheelbarrows; they also carry bricks on their heads.
- *Arranging bricks to dry*: children are also engaged in arranging the bricks on the land of the brickfield for drying.

The main aims of the present investigation were:

- to determine the prevalence of MSDs among child labourers in the brickfields and compare them with sedentary pre-adolescent workers in West Bengal;
- to identify unfavourable working conditions;
- to assess physiological and respiratory stress among child brickfield workers.

Materials and methods

Participants and study design

A child brickfield worker generally works helping a family member to earn the money for their family. Child workers work as cheap labourers in the brickfield industry of India, and they get some payment unofficially. However, due to the Child Act by the government of India, a small number of children were found for the study. In the cross-sectional study, only 112 child brickfield workers were selected for the study, of whom 66 were female and 46 were male subjects who were working in 28 selected brickfield units of Bhadrakali in Hooghly district, which is situated at the side of the Hooghly River, West Bengal. Children were also engaged in different household activities, e.g., as housemaids in India. One hundred and twenty control group subjects were also selected randomly, who were engaged in household jobs involving a minimum amount of hand-intensive tasks. The 112 child brickfield workers selected generally performed different types of manual work, which may cause the physical and biomechanical load. They carried the huge weight of mud, raw brick and baked bricks on their heads, which affected their health. The other 120 control subjects were generally workers in different types of household activities, like serving tea, water and food to members of the family in which they worked, on request.

The inclusion criteria of the study were that all the subjects were brickfield workers who had worked in the brick kilns for at least 1 year and were willing to take an active part in the study. The exclusion criteria of the study were that the selected subjects were not younger than 9 years and not older than 16 years.

Before the study, consent was obtained from brickfield owners, as well as from each child subject and the parents or local guardians of the child. Written permission for the project was obtained from the Institutional Human Ethical Clearance Committee of the Indian Council of Medical Research Guidelines.

Anthropometric measurements

The height and weight of the child brickfield workers and control subjects were measured by an anthropometer and a weighing machine, respectively. The body mass index of all the subjects was also computed.

Questionnaire study

A detailed modified Nordic musculoskeletal disorder questionnaire[5] was developed and applied to the child brickfield workers and controls in a local language. A questionnaire based on the modified Nordic musculoskeletal disorder questionnaire was completed by both groups. The questionnaire included questions about age, duration of occupation as a worker and daily working hours. This questionnaire also asked about type of work and about affected body parts (e.g., neck, shoulder, elbow, wrist/hand, upper back, lumbar, one or both knees, and one or both ankles/feet) among the child brickfield workers.

Measurement of hand-grip strength

Hand-grip strength was measured with the help of a hand-grip dynamometer. The child brickfield workers and the control subjects were asked to adopt an upright standing position without bending to one side, with arms at their side, not touching their body. They were instructed to grip the dynamometer with full force.[6]

Assessment of workplace temperature and humidity

The working environment of the brickfield was assessed in this study. The wet bulb globe temperature (WBGT) index was calculated to estimate the effect of temperature and humidity on child brickfield workers. Mean globe temperature and wet and dry bulb temperatures were also recorded. The formula for calculating the WBGT index for indoor conditions is:

$$\mathrm{WBGToutdoor} = 0.7 \times \mathrm{NWB} + 0.2 \times \mathrm{GT} + 0.1 \times \mathrm{DB},$$

where NWB is natural wet bulb, GT is globe temperature and DB is dry bulb temperature. Relative humidity was also estimated from a psychometric chart developed by Weksler Instruments (Stratford, CT, USA).

Assessment of radial pulse and blood pressure

Physiological parameters were recorded for the assessment of physiological workload of the child brickfield workers and control subjects by recording the heart rate of the workers prior to work and just after work in the brickfield. The resting 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 by the 10-beats method.[7] The blood pressure (BP) of the child labourers was measured with a sphygmomanometer and stethoscope before and just after completion of work.

Pulmonary function test

The pulmonary function test was performed with the use of a spirometer (RMS HELIOS 401). Three successive recordings of forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1) and forced expiratory ratio (FEV1/FVC ratio) were performed in the standing position, and the best of the three ratings was recorded. Peak expiratory flow rate (PEFR) was measured with a mini-Wright's peak flow meter (Clement Clarke International, HaagStreit, UK). The 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 three ratings was recorded.[8]

Data analysis

Data were examined using the statistical package Primer of Biostatistics version 5.0 (MSI Version=1.20.1827.0, Primer for Windows, McGraw-Hill). G-test was applied to determine whether or not the test item had any significant association with feelings of discomfort. The computed G-test statistical value was next compared for the chosen level of significance (p-value). Student's t test was also used to determine whether there was any significant difference between heart rate, BP and respiratory function values for the chosen level of significance ($p<0.001$) for the child brickfield workers and controls.

Results

The average age of the child brickfield workers was 12.8 years, and that of the control workers was 13.4 years. The average statures of the child brickfield workers and control workers were 143.9 cm and 142.6 cm, respectively. The average weights of the child brickfield workers and control workers were 31.5 kg and 32.9 kg, respectively. The average body mass indexes of the child brickfield workers and control workers were 15.4 kg/m^2 and 16.2 kg/m^2, respectively. The workers of the experimental group had worked for an average of more than 3.2 years, while the other group had worked for more than 4 years. The average daily duration of work for child brickfield workers was 7.1 hours/day, while for control subjects it was 8.6 hours/day.

From Table 1, it was observed that the lower-back region of the body was the most commonly affected part among the child brickfield workers (97%), with 43% of controls also reporting lower-back pain. This was followed by the shoulder region (88% of child brickfield workers and 27% of controls). The hands were the third most commonly affected region of the body in child brickfield workers (82%), with 21% of controls also reporting that their hands were affected. This was followed by pain in the wrist (76% of child brickfield workers and 19% of controls) caused by performing various types of hand intensive tasks both in brickfields and in households. The neck region of the child brickfield workers was also affected, with 73% of them reporting pain in the neck region, compared with only 21% of control workers. The ankles (71%), knee (69%), feet (54%), upper back (26%) and elbow (19%) of the child brickfield workers were also affected because of prolonged awkward working postures. This study also shows 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 child brickfield workers and the control subjects.

Physiological stress of the child brickfield workers and control group is shown in Table 2. This table illustrates that the resting heart rate of both groups did not show any significant change, whereas just after stoppage of work, the heart rates of both child brickfield workers and control subjects showed significant change. In the same manner, the resting BP (systolic and diastolic) of both groups (experimental and control) did not show any significant change. On the other hand, it was observed that the groups of subjects (experimental and control) did significantly differ in terms of BP (systolic and diastolic) just after completion of work. Table 2 also shows the comparison of the lung function parameters between the child brickfield workers and control subjects. There was a significant difference in spirometry findings (FVC, FEV1, FEV1/FVC ratio, PEFR) between the child brickfield workers and the control subjects. It was found that the changes in pulmonary variables in child brickfield workers in comparison with the control subjects were due to the constant exposure to dust in the brickfield, which decreases the healthy pulmonary status of the child brickfield workers. From Table 3 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 child brickfield workers and the control subjects. The average thermal environmental conditions of the brickfields have been described in Table 4, which indicates the thermal load among the child brickfield workers.

Figure 1 shows the comparative study of feelings of discomfort (pain) at different times among the child brickfield workers and control group participants. This study indicates that child brickfield workers felt maximum pain after work followed by sleep at night, whereas control subjects felt maximum pain during sleep. Figure 2 shows the different types of discomfort among the child brickfield workers and control subjects. In this figure, it was observed that among the feelings of discomfort, pain is the major one in the case of child brickfield workers and control subjects, followed by tingling and numbness. Figure 3 shows the occupational health problems among the child brickfield workers and control subjects. This study indicates that respiratory difficulties are one of the acute problems among the experimental subjects, followed by cardiovascular problems, gastrointestinal problems and eye irritation. In the case of control subjects, gastrointestinal problems are the major problem.

Table 1. Comparative discomfort (pain) in different body parts among child brickfield workers and the control group

Body parts	Child brickfield workers (n=112)	Control subjects (n=120)	OR	95% CI	G-value	p-value
Neck	82 (73.2%)	25 (20.8%)	10.38	5.65–19.06	29.15	<0.05
Shoulder	98 (87.5%)	32 (26.7%)	19.25	9.64–38.41	21.03	<0.05
Elbow	21 (18.8%)	09 (7.5%)	2.84	1.24–6.51	4.90	<0.05
Wrist	85 (75.9%)	23 (19.2%)	13.27	7.08–24.87	32.44	<0.05
Hands	92 (82.1%)	25 (20.8%)	17.48	9.08–33.62	29.76	<0.05
Upper back	29 (25.9%)	10 (8.3%)	3.84	1.77–8.32	10.21	<0.05
Lower back	109 (97.3%)	52 (43.3%)	47.51	14.27–158.15	10.15	<0.05
Knee	77 (68.8%)	15 (12.5%)	15.40	7.86–30.17	42.80	<0.05
Ankle	79 (70.5%)	16 (13.3%)	15.56	8.00–30.25	41.72	<0.05
Feet	60 (53.6%)	19 (15.8%)	6.13	3.31–11.34	23.88	<0.05

Table 2. Physiological and pulmonary function results among child brickfield workers and the control group

Physiological parameters	Child brickfield workers		Control subjects		t-value	p-score
	Mean	SD	Mean	SD		
Heart rate (beats/min)						
Resting	86.2	±5.82	87.7	±7.72	1.66	0.093
Just after work	166.5	±6.36	124.2	±6.28	50.95	0.000
Change of heart rate	80.3	±6.24	36.5	±6.65	51.64	0.000
BP (mm Hg)						
Systolic BP						
Resting	98.0	±2.32	97.3	±3.82	1.67	0.096
Just after work	132.2	±4.35	110.5	±5.46	33.33	0.000
Change of systolic BP	34.2	±4.32	13.2	±5.24	33.17	0.000
Diastolic BP						
Resting	62.5	±2.63	61.8	±3.32	1.77	0.078
Just after work	67.2	±2.48	65.3	±3.57	4.67	0.000
Change of diastolic BP	4.7	±2.44	3.5	±3.35	3.10	0.002
Pulmonary function tests						
FVC (litres)	2.04	±0.22	2.18	±0.25	4.51	0.000
FEV1 (litres)	1.82	±0.20	1.92	±0.21	3.70	0.000
FEV1/FVC (%)	89.21	±2.88	88.07	±3.12	2.88	0.004
PEFR (L/min)	262.8	±30.2	298.5	±32.5	8.65	0.000

BP: blood pressure; FEV1: forced expiratory volume in 1 s; FVC: forced vital capacity; PEFR: peak expiratory flow rate.

Table 3. Relationship between the hand-grip strength in the child brickfield workers and in the control group

Hand-grip strength	Condition	Child brickfield workers (n=112)	Control group (n=120)	F	p
At 90° elbow flexion (kg)	Resting condition	22.8±7.24	22.4±6.32	0.20	0.654
	Just after stoppage of work	20.2±5.88	22.0±5.26	6.05	0.015
At 180° elbow flexion (kg)	Resting condition	22.8±7.24	22.4±6.32	0.20	0.654
	Just after stoppage of work	19.8±6.12	21.7±5.34	6.37	0.012

Table 4. Average environmental temperature at the brickfield in different seasons

Environmental parameters	Mean	SD
Natural wet bulb temperature (°C)	35.1	±3.21
Dry bulb temperature (°C)	38.7	±2.32
Globe temperature (°C)	40.3	±1.92
Air velocity (m/s)	0.42	±0.15
Relative humidity (%)	91%	±5.88
WBGT (°C)	36.5	±1.88

WBGT: wet bulb globe temperature.

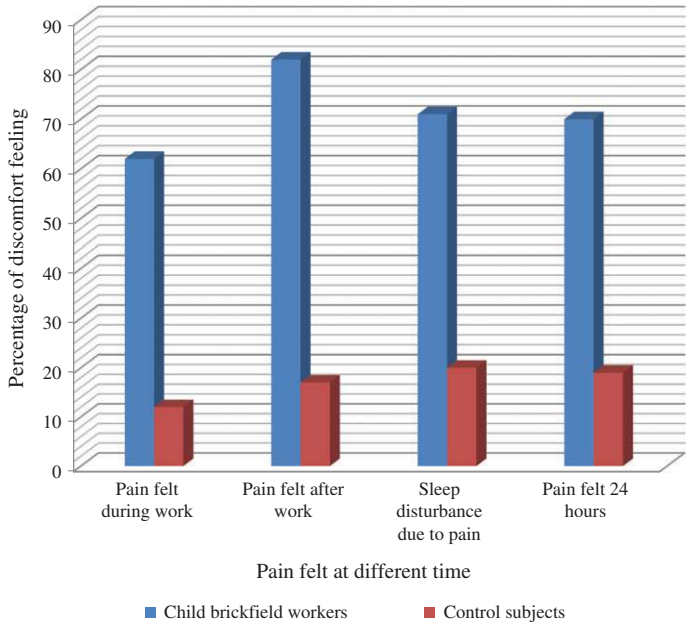

Figure 1. Comparative study of feelings of discomfort (pain) at different times among the child brickfield workers and control group participants.

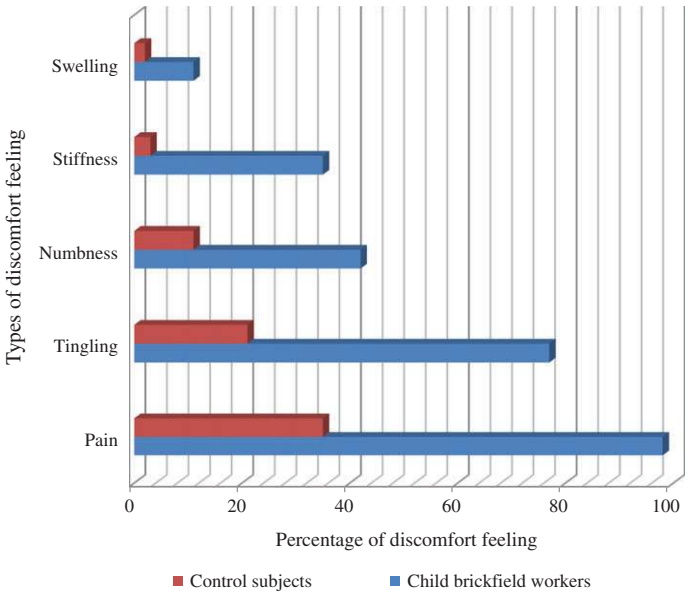

Figure 2. Types of discomfort among the child brickfield workers and control subjects.

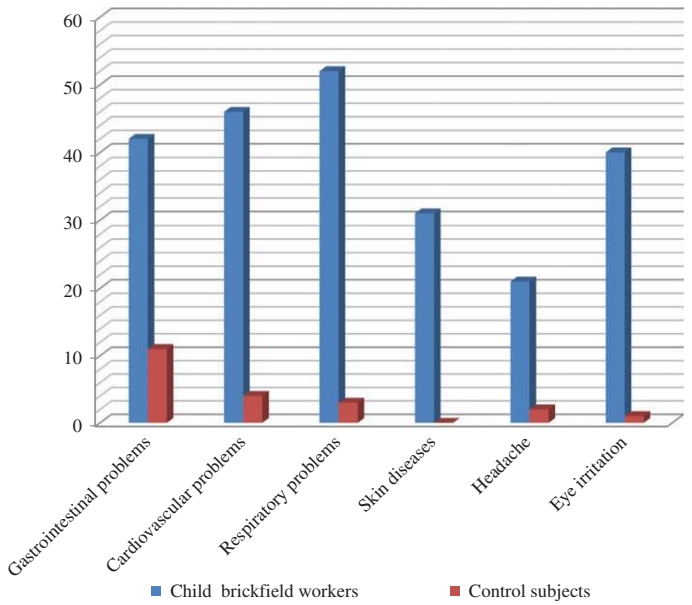

Figure 3. Occupational health problems of the child brick field workers and control subjects according to the questionnaire study.

Discussion

Brick manufacturing is one of the important industries where children and adolescents are considered an integral component of the workforce.[9] Child labour remains a widespread problem throughout the world.[10,11] According to the International Labour Organization, more than 218 million children in the world today are involved in child labour, often doing work that is damaging to their mental, physical and emotional development. At least 126 million children are performing hazardous work. Child labour has negative effects on the health and development of the children.[10] The Child Labour Regulation Act (1986) stipulates that anyone employing children in work that is hazardous to their well-being would be liable to prosecution and other penal action. However, in the case of child labour in the brickfields, the application of this law is difficult as brick owners do not employ children directly. The child labourers do not get any payment for the work directly, and they do not have their names in their muster rolls; they just help their family members to earn the money by doing their work, and they get some payment unofficially, which is very important for their family.

Child brickfield workers are mainly involved in different activities related to brick manufacturing. Most of those workers come from poor socio-economic backgrounds. They are compelled to perform brick-making activities along with other family members so that they can earn money to help their family and to meet their everyday needs, which may affect their physical

health. The prevalence of occupational health hazards has been reported to be high among children. In this study, it is evident that the child brickfield workers performed the highly strenuous activities associated with brick making in brickfields in an awkward posture for prolonged periods of time, which may lead to MSDs. This result corroborates the work of Das.[12] It was stated, in his previous research, that the adult brickfield workers also suffered pain in different parts of the body due to working in an awkward posture for prolonged periods of time. Gangopadhyay et al.[13] also found the same results among child agricultural workers.

The Primary findings from the study were different physical risk factors like awkward posture, repetition of work and manual material handing probably leads to the high prevalence of MSDs among child brickfield workers. This study showed that child brickfield workers suffered from pain in different parts of the body, especially in the lower back, knees and upper extremities. The study mainly shows that the physical and the biomechanical load of the child brickfield workers is high in comparison with the control group of workers due to carrying heavy loads in an awkward posture for prolonged periods of time. The present study also shows that, among the brick-making activities, digging for mud collection is the most strenuous activity. This result corroborates the work of Das and Gangopadhyay.[14] According to these authors, child labourers face a lot of discomfort during spading due to working in an awkward position and the work being highly repetitive.

This study presents evidence confirming that the work of children in brickfields is strenuous. Consequently, the child brickfield workers suffer from MSDs arising from a number of causes—the most relevant being the adoption of a constrained awkward squatting, kneeling or stooping posture for prolonged time periods. Posture, especially severe flexion or lateral twist and bending, has been found to be significantly related to lower back pain.[15] Posture and location and weight of a load affect the moment of force applied in the lumbar region, which in turn affects muscle loading and compressive forces on the internal vertebral disc.[16] Choobineh et al.[17] also found that musculoskeletal problems among carpet weavers can be mainly attributed to poor working postures. Keyserling et al.[18] also stated that prolonged squatting postures can gradually cause MSDs in 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 child brickfield workers and the control group. If child brickfield 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. This result also corroborates with the work of Alperovitch-Najenson et al.[19] According to these authors, workers constantly engaged in hand-intensive jobs are likely to suffer from upper-limb MSDs. The results from this study revealed that the decreased hand-grip strength may be related to increased loading at the muscles at the cervical spine and shoulder joints. Das[20] also stated that, due to the prevalence of malnutrition among child brickfield workers and the high physical activity, the preadolescent brickfield workers have a weaker hand-grip strength than control subjects.

The physical factors and external ambient environment for the brick-making job were found to have many risks. Child brickfield workers, especially moulders, carriers and stackers, were exposed to the heat for longer durations; additionally, the workers are also exposed to high concentrations of dust, fumes and particulate. Most child brickfield workers reported physiological stress during different activities in the process of brick making. When child brick carriers bend 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. This study also revealed that the heart rate of child brickfield workers just after work was 166.5 beats/min, which was very high in comparison with the recommended limit of 110 beats/min for an 8-hour work shift. Thus, the majority of the tasks in the brickfield can cause high cardiovascular strain during an 8-hour workday, and may cause fatigue and higher muscular strain in workers, with associated muscular pain. Sett and Sahu[21] reported in a similar vein to this study, finding that with increasing levels of physiological parameters, due to increasing ambient temperature and heavy physical work, repetitive and continuous movement attributes to an exposure–response relationship between sickness and forceful, repetitive work.

Dust concentration in and around the brickfield is very high. This dust during brick making is injurious to the child brickfield workers along with the population living in the vicinity of brickfields and causes various respiratory diseases.[8] The results of the study clearly demonstrate a reduction in lung function of child brickfield workers compared with control subjects. This result corroborates the work of Shaikh et al.[22] They also stated that respiratory illness was more acute in brickfield workers in comparison with a normal population. This study also revealed that the lung function values of the child brickfield workers were significantly lower in comparison with control subjects. Child brickfield workers are generally exposed to free silica during the making of green bricks (moulding) and during hacking. The possible explanation for these lower lung function values in brickfield workers is higher exposure to air pollutants. The estimates of the symptoms mentioned previously are also quite similar to previous studies done on workers exposed to dust and smoke in other occupations.[23,24] This study also showed that the PEFR values of brickfield workers were lower in comparison with the control groups. The findings of Das et al.[25] were same. They also stated that the PEFR value was lower among the construction workers in comparison with control subjects.

Strengths and limitations

The main limitation of the present study is the cross-sectional design, which makes it difficult for generalizing to the study population or community. Another limitation is that the subjective method of data collection is usually time consuming. The main strengths of the study are its sample size and its subject matter, which is a nationwide serious problem among children.

Recommendations

Recommendations include trying to use fly ash bricks in construction instead of manual brick because it reduces dead load on structures due to their light weight. Workers should try:

- to avoid awkward postures and avoid working for prolonged periods;
- change the work schedule by increasing short rest breaks in their work to avoid excessive physical stress.

Different types of stretching exercises should be practiced during the breaks. Job rotation among the child brickfield workers should also be considered. Different types of masks should be used, especially during moulding, digging, loading and unloading bricks from the kiln in order to avoid the dust particles.

Conclusion

The conclusions reached from this investigation are as follows:

(1) This study indicates mainly that child brickfield workers are suffering from MSDs (especially in the lower back, knee, shoulder, hand and neck) due to stooping, squatting and twisting postures, held for a prolonged period of time with a high amount of repetitiveness.
(2) Child brickfield workers have lower hand-grip strength, due to the performance of more strenuous work in a brickfield, in comparison with control subjects.
(3) This study concludes that during heavy physical activities in brick making, the heart rate becomes high among the child brickfield workers. Enhanced post-activity heart rate can be the result of severe physiological stress generated by an enormous workload.
(4) These studies conclude that the lung function values of exposed child brickfield workers were lower in comparison with non-exposed control subjects. This may occur due to the inhalation of dust during working in the brickfield.
(5) This study shows that the PEFR values are much lower among child brickfield workers because of inhalation of dust particles in the brickfields.

Author's contributions: BD, in his research project, contributed to the proposal writing, participated in interviews, conducted the literature review and data collection, analysed the results, and wrote and edited the manuscript. BD has undertaken all the duties of authorship and is guarantor of the paper.

Acknowledgment: The author is thankful for the grant provided by the University Grant Commission, India, for partial funding of the study. The author also expresses his sincere gratitude to all the child brickfield workers and control subjects, as well as their parents and brickfield owners who gave consent for participation in the study.

Funding: The project was financially partially supported by the University Grant Commission (India) [UGC Reference No. F. PSW-147/11-12 (ERO)].

Competing interests: None declared.

Ethical approval: Written permission for the project was obtained from the Institutional Human Ethical Clearance Committee of the Indian Council of Medical Research Guidelines.

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