International Journal of
Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Risk of work-related musculoskeletal disorders and occupational health hazards among the footwear making workers in West Bengal, India

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Date of submission: 03.05.2025
Date of acceptance: 14.04.2026
Date of publication: 10.07.2026

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v16i2.77950

ABSTRACT

Introduction: Shoe making industry is one of the largest industries of the country which employs more than 1.10 million workers coming from the rural areas. They are exposed to different types of occupational hazards at the workplace. Musculoskeletal disorder (MSD) is one of the major burdens among the workers.

Methods: In this comparative study, physiological and demographic characteristics of the randomly selected shoe making workers (150) and non-teaching staff of schools (150) were measured by standard physiological methods and surveys. The study was conducted in the month of February to April 2025 in Nadia district, West Bengal. Modified Nordic questionnaires and body part discomfort (BPD) scale was used to record the musculoskeletal disorders and degree of pain felt. Rapid Entire Body Assessment (REBA) was used to evaluate the working postures.

Results: In this study, it was found that shoe making workers were suffering from excess fatigue (88.66%), accidents (92.00%), addiction (78.66%), and MSDs (96.66%). It was observed that wrist (OR-21.98, 95% CI- 10.06-48.04, p - <0.0001) was the most affected body parts followed by neck, hip, lower back *etc.* due to pulling, bending and twisting postures as well as repetitive actions. Strong significant correlation had been found between MSD with age less than 30 years (OR-11.70, p - <0.0001) and experience up to 5 years (OR-3.73, p - 0.0001).

Conclusion: Shoe making workers were suffering from different types of occupational stress and adverse working conditions. Proper working postures, work-rest cycle, training, and frequent medical check-up can reduce the occupational stress among them.

Keywords: Body parts discomfort (BPD) scale, Rapid Entire Body Assessment (REBA), Shoe making workers, Work- related musculoskeletal disorder (WMSD)

Introduction

The Indian footwear industry is one of the leading industries in the country's employment status and economic development. India poses second position after China in footwear production with an annual production rate of 2.58 billion pairs (2018).[1] The market size of the Indian footwear industry is USD 17.89 Billion (2024).[2] Major footwear production cities of India are Chennai, Mumbai, Kanpur, Jalandhar, Agra, Kolkata, Pune, Delhi, Ludhiana and Faridabad where more than 1.10 million workers are engaged in this footwear manufacturing and production industry.[3] Most of the workers engage in this occupation through unorganized small factories. The footwear manufacturing process is mainly done through manual process.

Till today, shoes are getting more priority than the shoe makers.

In the shoe making process, different hazardous chemical substances such as benzene, toluene, xylene, n-hexane etc. are present in the adhesive which has several toxic effects such as cancer, respiratory disease, neurotoxicity etc.[4,5] Aplastic anaemia, leukaemia and other serious health problems were also reported among the child labour of this industry due to exposure in high toxic solvents.[6] In this footwear manufacturing industry, dust particles and adhesive affected the workers lung capacity and also peak expiratory flow rate (PEFR) reported by Gangopadhyay et al.[7]

Musculoskeletal disorder (MSD) is known as the pain, numbness or discomfort in the joints, ligaments, muscles as well as in the tendons and it is one of the most common occupational disorders among the workers. Leite et al. reported that shoe manufacturing workers suffered from multisite work-related musculoskeletal disorder (WMSD) especially in shoulder and wrist regions with special relation to the biochemical, mechanical and psychosocial factors.[8,9] Excessive physical work load, restlessness, obesity and smoking were also causing multisite WMSD among the workers.[10] Work ability reduction, request for disability retirement and absenteeism due to WMSD was significantly reported among the workers in this footwear industry.[11,12] WMSDs arise by different factors such as physical, physiological, environmental as well as psychosocial.[13] According to Almeida et al., significant correlation had been observed between MSD and perceived stress among the footwear manufacturing workers.[14] Judyangel et al. showed significant risk of respiratory disorders, skin alignment and musculoskeletal problems among the leather footwear manufacturing workers.[15] Jadhav et al. found that the most affected area of MSDs is lower back followed by neck, thigh, shoulder, wrist, knee among the hand-sewn crafted footwear workers in Kolhapur, India.[16] As reported by Riaz et al., the cobblers of Faisalabad, Pakistan suffered from neck and shoulder pain.[17] According to Sarkar et. al., these shoe manufacturing workers suffered from pain in their limb joints, lower back and neck region.[18]

These footwear manufacturing workers are exposed to different types of occupational health hazards regularly. They are also suffering from different types of occupational diseases and disorders. Several hazardous working environments are also accelerating these occupational diseases and disorders among them.

So, the main aim of this present study is to find out the factors which cause the musculoskeletal disorders and different occupational health hazards among these shoe making workers of West Bengal, India.

Methods

Most of the footwear making small scale factories in West Bengal, India are maintained by private parties. Due to lack of direct government observations in these private factories, workers who are involved in this field are often suffered from different types of occupational health hazards. In Nadia district, West Bengal, nearly 400 workers are engaged in the shoe making process through different unorganized (private) small footwear making factories. So a comparative study had been design to evaluate different occupational problems among these shoe making workers. For this present study, the data was collected through the survey which includes age, sex, educational details, demographic characteristics, job details of the subjects. The survey sheet contained objective types MCQ questionnaire which was communicated through local language to the workers.

Physical and physiological parameters of the subjects were measured according to standard methods. Modified Nordic questionnaire was used to study the MSDs and psychological stress of the workers.[19] In MSDs, pain or discomfort in nine different regions of the body such as neck, shoulders, elbows, wrists/hands, upper back, lower back, hips, knees, and ankles/feet during last 7 days were recorded for this survey. Body Parts Discomfort (BPD) scale was used to measure the intensity of pain feeling of the subjects. BPD scale uses 1-10 scores of discomfortibility/pain where 1= identifiable pain, 5= moderate pain and 10= intolerable pain.[20] Rapid Entire Body Assessment (REBA) method was used to evaluate the working postures of the subjects.[21] Videography of the each working cycle was done by IPhone 13 Pro max (USA), and each videography freeze-framed at 20 seconds interval for getting the frequently maintained postures. Most frequently maintained posture of each part of the shoe making process and working activities of non-teaching staff had been selected and stick diagrams were made from freeze framed videography for the posture analysis by REBA method. Inside the shoe making factories, different environmental parameters such as dry bulb temperature (DBT), Wet bulb temperature (WBT), Relative Humidity (RH) were also recorded by SILVA ADC Pro (Sweden) whereas illumination level, noise level and UV radiation was measured by lux meter (Mastech MS6610, India), digital sound meter (Metravi SL4005, India) and UV meter (Lutron UV-340A, USA) respectively. Heat stress inside the factories was calculated by Wet bulb globe temperature (WBGT) index.[22]

This survey was conducted in the month of February to April, 2025 at different shoe making factories and high schools of Nadia District, West Bengal, India.

The present study had been approved by the Departmental Research Committee, Department of Physiology, Murshidabad University (Memo No. – MU/Physiol/01-02/25). This study was conducted according to the Helsinki Declaration (2013) where written consents had been taken from all the participants. The objectives of this study were also clearly explained (Layman terms) to all the subjects.

In this study, the inclusion criteria for shoe making workers (SW) were age (16 to 65 years) and experience (minimum 1 year) and for the control group (CG) were subjects having a minimum of one year full working experience and age between 22 to 60 years. In this study, the subjects who had any past history of orthopedic disorders and had an earlier history of accidents outside the working place were excluded from the survey.

For the present study, 150 male shoe making workers (SW) out of 188 workers were randomly selected from 12 small factories (unorganized sector) of Nadia district, West Bengal, India. For the control/referent group (CG), 150 male non-teaching employees (group-c and group-d staff) out of 182 employees from 12 high schools (organized sector) of the same district were randomly selected for this comparative study.

All the survey data were entered into the MICROSOFT EXCEL sheet to calculate the average (mean) value, standard deviation (SD) value, frequency and percentage. MATLAB 7.0.4.365(R144) service pack 2 software tool was used to calculate the t-test, Odd Ratio (OR), 95% Confidence Interval (CI) and p-value.[23]

Results

In this present study, different physical, physiological, demographical, psychosocial parameters and job details had been collected from the shoe making workers as well as non-teaching staff of different high schools of Nadia district, West Bengal, India. Physiological parameters with job details of the study are shown in Table 1. The mean age of the shoe making worker was found 30.28 ±13.42 years ranging from 16 to 65 years whereas in the control group, the mean age was found 40.72±10.05 years ranging from 22 to 60 years. From the BMI calculation it was found that 89(59.33%) workers were under normal range but 52(34.66%) workers were found BMI less than 18.5. Mean systolic and diastolic blood pressure (BP) was 130.6±22.59 mmHg and 79.77±12.87 mmHg in case of workers whereas 133.89±14.22 mmHg and 81.02±10.91 mmHg in case of control group. Haemoglobin value (Hb) and random blood sugar (RBS) were also measured where it was observed that both the parameters found high among the non-teaching staff of the schools compared to the shoe making workers (13.31±0.99 gm/dL and 112.81±22.62 mg/dL). These shoe making workers had an average working experience of 11.94±10.77 years whereas 68(45.33%) of them were working in this field for more than 10 years. Average daily working hours of these shoe making workers was 10.91 hours whereas 81(54%) workers were engaged more than 12 hours per day. They were taking tiffin breaks ranging between 30 to 180 minutes per day with an average of 67.9 minutes per day. The BPD score was found higher in case of SW than CG. The student's t-test had been done between the experimental and control group where significant differences were found in case of age, BMI, Hb value, working hours per day, tiffin hours and BPD score.

Table 1: Physiological parameters with working details

Parameters	SW (n=150)/CG (n=150)	*t - Value*	*p - value*
Age (year)	30.28±13.42 / 40.72±10.05	7.5908	<0.0001
BMI (kg/m^2)	19.92 ±3.10 / 24.57±3.25	12.6451	<0.0001
< 18.5	52(34.66%) / 03(2.00%)		
18.5 - 25	89(59.33%) / 84(56.00%)		
> 25	09(6.00%) / 63(42.00%)		
BP Systolic (mmHg)	130.60±22.59 / 133.89±14.22	1.5143	0.1310
BP Diastolic (mmHg)	79.77±12.87 / 81.02±10.91	2.3222	0.0209
Heart Rate/min	77.89±11.70 / 79.28±13.05	0.9031	0.3672
Hb (g/dL)	13.31±0.99 / 14.62±01.11	10.7101	<0.0001
RBS (mg/dL)	112.81±22.62/126.21±47.35	3.1307	0.0019
Working Experience (year)	11.94±10.77/13.54±09.55	1.3002	0.1945
Working hours (per day)	10.96±1.31/6.67±01.33	28.6455	<0.0001
Tiffin Hours (min/per day)	65.73±44.66/30.00±05.00	10.9744	<0.0001
BPD Score	5.31±1.44/4.50±01.89	4.3600	<0.0001

In this present study, odd ratio of different occupational problems was calculated and presented in Table 2. It was noted that significant risk of tiredness (OR-4.40; 95% CI- 2.40-8.05), MSDs (OR-20.43; 95% CI- 7.91-52.77) and addiction (OR-14.15; 95% CI- 8.12-24.67) were also present among these shoe making workers (Table 2). Both the groups i.e. SW and CG were equally suffering from headache as shown from the Table 2.

Table 2: Analysis of odd ratio of occupational problems

Occupational problems	SW [n=150 (%)] / CG [n=150 (%)]	OR[23]	95% CI	*p – value*
Accidents (Yes)	138(92.00%) / 41(27.33%)	30.57	15.32-60.99	<0.0001
Headache	91(60.66%) / 90(60.00%)	1.02	0.64-1.63	0.9061
Feeling tired after work	133(88.66%) / 96(64.00%)	4.40	2.40-8.05	<0.0001
Eyesight Problem	65(43.33%) / 78(52.00%)	0.70	0.44-1.11	0.1334
Hearing Problem	16(10.66%) / 27(18.00%)	0.54	0.27-1.05	0.0727
MSDs	145(96.66%) / 88(58.66%)	20.43	7.91-52.77	<0.0001
Addiction	118(78.66%) / 31(20.66%)	14.15	8.12-24.67	<0.0001

Wrist was found as the most significantly affected body parts of the workers (OR-21.98; 95% CI- 10.06-48.04) followed by neck (OR-11.20; 95% CI- 6.50-19.29), hip (OR-9.11; 95% CI- 5.32-15.59), lower back (OR-5.37; 95% CI- 3.21-8.99), upper back (OR-5.09; 95% CI- 2.43-10.63), whereas high risk of elbow and knee pain were also observed among these workers as shown in Figure 1.

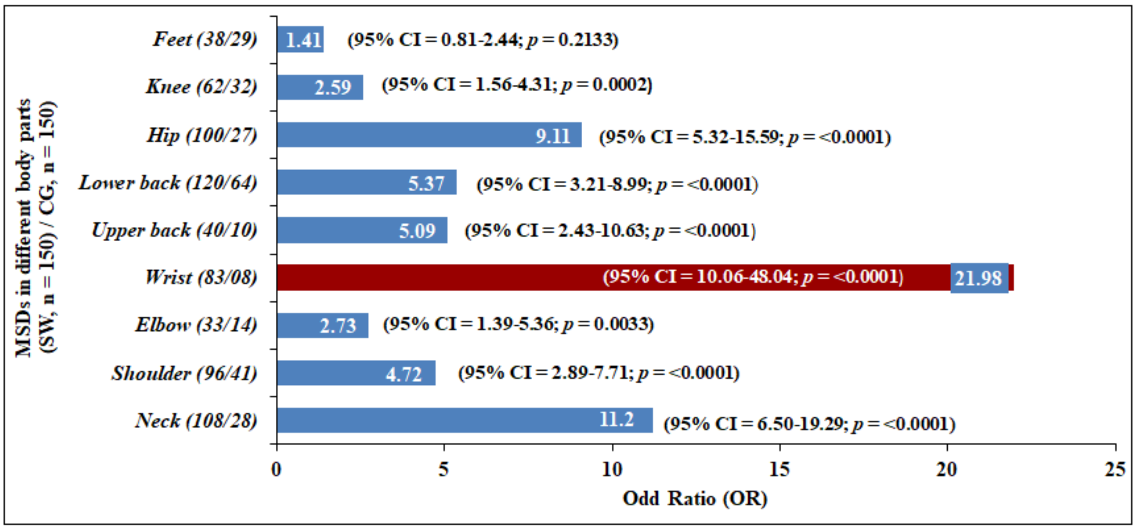
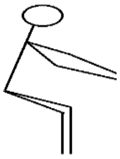
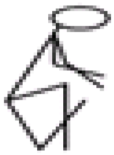
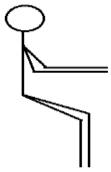
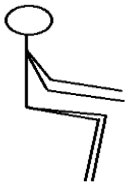
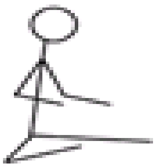
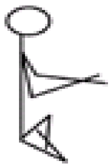
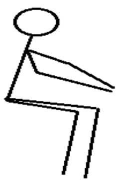
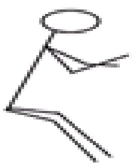


Figure 1: Musculoskeletal disorders in different body parts with Odd Ratio[23]

Table 3: Analysis of Odd Ratio between MSDs with age and work experience

	SW [n = 145 (%)] / CG [n = 88 (%)]	OR[23]	95% CI	*p - value*
MSDs with Age				
< 30 years	87 (60.00%) / 10 (11.36%)	11.70	5.59-24.45	<0.0001
≥ 30 years	58 (40.00%) / 78 (88.63%)	0.08	0.04-0.17	<0.0001
MSDs with work experience				
Up to 5 years	63 (43.44%) / 15 (17.04%)	3.73	1.96-7.12	0.0001
5 - 10 years	24 (16.55%) / 25 (28.40%)	0.49	0.26-0.94	0.0330
> 10 years	58 (40.00%) / 48 (54.54%)	0.55	0.32-0.94	0.0314

Table 4: Posture analysis of shoe workers and non-teaching staff by REBA method

Shoe making workers				Non-teaching staff			
Stick diagram & process	**REBA score with comment**			**Stick diagram & process**	**REBA score with comment**		
	Right	**Left**			**Right**	**Left**	
 Hammering	8	8	High risk	 Office table task 1	7	6	Medium risk
 Pasting	6	6	Medium risk	 Office computer task	3	3	Low risk
 Upper making	9	10	High risk	 Office table task 2	3	3	Low risk
 Cutting	7	6	Medium risk	 Office task (standing)	3	3	Low risk
 Fitting	6	6	Medium risk	 Laboratory task	6	7	Medium risk
 Stitching	11	11	Very high risk	 Laboratory task (standing)	5	6	Medium risk

In this study, it was observed that 145 shoe making workers and 88 non-teaching employees of schools were suffering from MSDs. Odd ratio calculation of MSDs with age and working experience was also done where it was observed that shoe making workers less than 30 years of age (60.00%) were more prone to MSDs. It was also found that workers up to 5 years of working experience (43.44%) showed significantly higher risk of MSDs compare to non-teaching employees (17.04%) as shown from Table 3.

In this study, most frequently maintained working postures of shoe making workers and non-teaching staffs were analyzed by REBA method (Table 4). In the small scale shoe making factory, every worker who engaged in this shoe making process followed different steps such as hammering, pasting, upper making, cutting, fitting and stitching. It is found that hammering and upper making postures fall in the high risk category whereas stitching posture is categorized in the very high risk level as shown in Table 4. Every non-teaching employee of schools is involved in different office works as well as laboratory activities. Frequently maintain working posture analysis of these staff by REBA method revealed that office table task 1 and laboratory tasks fall in the medium risk category as shown in Table 4.

BPD score was measured and plotted with age, experience, education, working hours and tiffin break (Figure 2). From this figure it is found that BPD scores rise with increasing age and experience whereas it is inversely proportional with educational level and tiffin break. It is also noted that the highest BPD score (5.40) recorded among the workers with daily working time up to 8 hours followed by working time ≥ 10 hours.

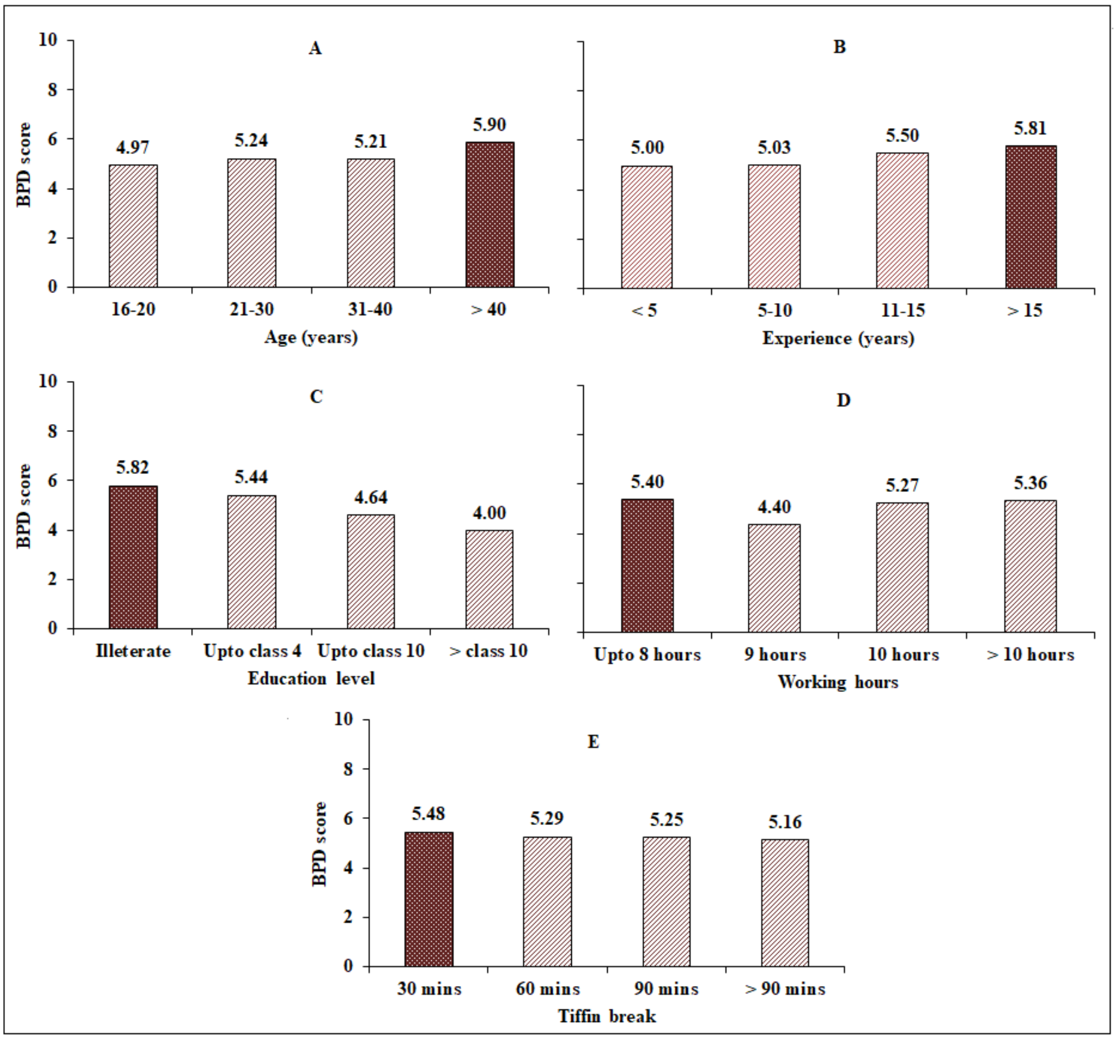


Figure 2: Analysis of BPD score with age (A), experience (B), education (C), working hours (D) and tiffin time (E)

Table 5: Environmental parameters inside the shoe making factories

Parameter	Average ± SD	Maximum	Minimum
DBT (°C)	33.1 ± 0.8	33.9	30.7
WBT (°C)	28.1 ± 1.1	29.3	26.3
WBGT (°C)	29.6 ± 0.8	30.5	27.6
RH (%)	78.9 ± 5.2	84.8	67.4
LUMI (lux)	44.0 ± 19.1	88	14
NOISE (dBA)	69.8 ± 8.4	91.4	60.4
UV (nm)	16.2 ± 5.1	30.0	10.0

Mean dry bulb temperature (DBT), wet bulb temperature (WBT) and wet bulb globe temperature (WBGT) of the workplaces were found as 31.4°C, 28.1°C and 29.1°C respectively with an average relative humidity of 78.9%. Illumination, noise and UV radiation was also measured which was found 44.0±19.1 Lux, 69.8±8.4 dBA and 16.2±5.1 nm respectively (Table 5).

Discussion

The shoe making process is dominated by male workers in India. In Nadia district, West Bengal, mostly local village people are engaged through very small-scale industries which are run mainly by private parties. Earning of these workers depends on their working hours and production rate per day, hence they have an average 11 hours of daily strenuous working hours which is more than the recommended working time.[24] In this study, significant difference had been observed in case of BMI, Hb value, working hours per day, tiffin hours and BPD score. It was found that more than 1/3rd of our study population had lower BMI but the majority of the workers had normal BMI. The study of Leite et. al. showed that nearly 50% Brazilian footwear manufacturing workers had normal BMI whereas only 5% had lower BMI.[8] Prolonged working hours (more than 11 hours), repetitive work style and adverse working environmental conditions (high temperature and humidity, low light) might be the reason behind the significantly higher rates of accidents, fatigueness and MSDs. The long working hours, stressful working environment with low pay lead them towards the poor living conditions which may get them addicted to smoking and alcoholism which was found in this study. They maintain different types of poor body postures during prolonged working hours which cause MSDs in different body parts of them. In this comparative study, it was observed that the highest risk of MSD found in hand/wrist (OR = 21.98, 95% CI = 10.06-48.04, p = <0.0001) part of the body among the workers followed by neck, hip, lower back, upper back, shoulder, knee and elbow. According to frequency analysis of MSDs among the workers, it was found that 80% workers were suffering from lower back pain followed by neck, hip, shoulder, wrist, knee, upper back, feet and elbow pain. These shoe making workers used different types of hand tools, performed repetitive and forceful hand intensive tasks as well as bullying in this shoe making process which might be the reason behind the highest risk of hand/wrist MSDs and this study is also supported by Barr et. al.[25] This pain or discomfort in hand/wrist region was worsened when workers performed such tasks in awkward or extreme wrist forearm postures.[26,27] In these shoe making process, workers maintained a prolonged forward bending neck posture which might be the cause of high neck pain or discomfort. This result corroborated by the observations of Cagnie et. al.[28] Significant risks of hip and lower back pain were also observed among the workers in our study. Five out of six different steps of shoe making processes were found in the risk category where workers were in sitting or squatting on the floor with their legs and knee bending position as well as maintaining forward bending and twisting posture. This result is also supported by the observation of Fransen et al. and Quynh et al.[29,30] Forward bending and twisting back postures affects the vertebral disc and surrounding spine muscles which can cause lower back pain or discomfortability.[31] Several studies have shown that shoe making workers were suffering from different WMSDs due to prolonged maintained of awkward postures, perceive stress, bullying, biomechanical and psychological factors.[8,9,14,15,18,32] This fully handmade shoe making process have different steps such as hammering, pasting, upper making, cutting, fitting and stitching. Every worker followed these steps for making shoes and most of the steps are manually handled. In this shoe making process, workers maintain different types of working postures for a prolonged period of time. In this study frequently maintained working postures were analysed by REBA method which showed that pasting, cutting and fitting postures have fallen in the medium risk category due to forward bending (20°), twisting of neck, trunk and wrist positions. Hammering and upper making postures had fallen under the high risk category due to forward bending (>20°), twisting of neck, trunk, lower arm and wrist position with high REBA activity score. Stitching posture had been categorized as very high risk (highest REBA activity scores) due to forward bending and twisting of neck and trunk; abducted upper arm and lower arm position; bend and twisted wrist position as well as bending leg action (>50°). Several studies had shown that shoe making workers were suffering from MSDs due to maintaining prolonged awkward working postures.[8,21,27,33] In this present observation it was also noted that shoe making workers less than 30 years of age and up to 5 years of work experience had significantly high risk of developing MSDs when compared with referent group.

In this study, more than 96% shoe making workers were suffering from different types of MSDs. This MSDs or discomfortability was measured by BPD scale and plotted with age, experience, education, working hours and tiffin break. It was noted that discomfortability or pain feeling increased with age (might be due to decreased mobility, increased fatigueness and stiffness in muscular system), experience (might be due to overconfidence, carelessness, impatient about the work) and working hours (might be due to fatigueness, over time, increased psychosocial stress and reduce work-rest cycle). Similar observations were also found by Letie et al. and Haukka et al.[8,10] It was interesting to observe that BPD score inversely proportional with education level which might be due to proper knowledge and education among the literate/educated workers. This BPD score was also inversely proportional with increased tiffin break which might be due to increased work-rest cycle leading to decrease the muscular tension, reduce continuous work load and recovery from fatigue. Our present finding is also supported by the observations of Palsson et al. and Martinez et al. regarding the effects of educational status and work-rest cycles on MSDs respectively.[34,35]

It was observed in this study that workplace temperature reaches 33.9°C with an average 33.1°C which is beyond the recommended level.[36] Relative humidity inside the shoe factories was also found very high. High WBGT at workplace was also noted in our study which indicate the heat discomfortability among the workers according to USARIEM.[37] High air temperature with humid working condition might lead the workers to severe discomfort and psychological stresses which could increase the work place accident rates.[38,39] High risk of MSDs, very high workplace accident rates (92%) and heavy tiredness (88%) after the daylong hard work among the shoe making workers were also found in this study which might be due to high workplace temperature with humidity, prolonged duration of work, poor working conditions, lack of personal protective equipment and mental stress. Our present observations are also supported by the research work of Leite et. al. and Vieira et al.[8,40] Workplace illumination level was found very low than the factories' recommended level (750 Lux).[41] A large number of these shoe making workers were suffering from frequent headache problems and accidents which might be due to very low illumination level and adverse working environmental conditions and these results have also been supported by the observations of Katabaro et. al. and Li et al.[42,43]

Suboptimal sample size, short term observations, lack of seasonal variations of working environmental parameters etc. were the limitations of the present study.

Conclusion

These shoe making workers mainly comes from socio-economically lower sections of the rural areas. In this present study it is observed that these shoe making workers were suffering from different types of occupational hazards and health related problems along with WMSDs. To prevent the occupational hazards and musculoskeletal problems among the workers, few measures can be taken such as maintain proper sitting support, incorporation of semi-automated or automated process as much as possible, proper work-rest cycle, comfortable working environment, awareness campaign, proper education and training, as well as periodic medical health check-up. To promote the health status as well as to prevent the occupational stress of these workers, government and non-government initiatives should be encouraged.

Acknowledgement

Author is thankful to Murshidabad Maharaja Krishnanath University for providing the opportunities and support to conduct the present study. One of the authors is grateful to Santipur Municipality, West Bengal for the support to conduct the study. All the subjects who participated in this study are thankfully acknowledged. Authors are grateful to the researchers/scientists whose papers are cited in this article.

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