Research Article

Occupational health hazards among yarn dyeing workers of Santipur and Phulia in the Nadia district of West Bengal

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ABSTRACT

Background: The handloom sector is one of the important sectors which carries cultural heritage and give socioeconomic stability of the villages. **Objective:** The aim of the study is to identify the occupational risk factors of the workers present in the textile yarn dyeing units of Nadia district, West Bengal, India. **Materials and Methods:** A total of 167 male workers from 24 cottage based industry are randomly selected for the present study. Physical and physiological parameters along with personal details of the subjects are collected. 399 postures of 40 main tasks of dyeing process are analyzed by Ovako working posture analysis system along with other environmental parameters. Statistical analysis is used to evaluate mean value, standard deviation, odds ratio, 95% confidence interval, and level of significance for the link of work-related musculoskeletal disorders with different variables. **Result:** It is observed that accident rates are high among very small scale units' workers in comparison with small-scale units' workers. The workers maintain different awkward postures during their prolonged working hours without a proper work-rest cycle. Due to high workplace temperature and humidity, low illumination level and wrong body postures more than 85% workers feeling very tired or fatigue after the work. **Conclusion:** Awareness about the risk factors of the working environment can minimize the occupational health hazards of yearn dyeing workers.

KEY WORDS: Yarn Dyeing; Socioeconomic Stability; Posture; Occupational Health; Ovako Working Posture Analysis System

INTRODUCTION

In India, the textile industry is one of small-scale industries, and a part of its production (15%) is handloom textile sectors. After agriculture, handloom sector is the 2nd largest sector where most of the employees are village people, particularly from lower socioeconomic groups. About 4.3 million people are directly or indirectly involved in different handloom textile units and contribute 95% of worlds' handloom sector.[1]

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This sector not only provides with socioeconomic stability of villages but it also carries cultural heritage and rich diversity of the nation. At Shantipur and Phulia in West Bengal, more than 90 dyeing units have been actively working to produce 60% colored yarn and 40% gray yarn to meet the need of the weaving units of the area.[2]

Nowadays, work-related musculoskeletal disorders (WMSDs) are the most common occupational problem for both developing and developed countries, and it not only affects the workers' efficiency but at the same time it also affects their socioeconomic status as well as reduces productivity and increases the wage compensation cost while wasting millions of working hours.[3-5] Poor and awkward working postures are the main reasons behind these (MSDs) according to many scientists round the globe.[6,7] As most of the dyeing units are unorganized and under private entrepreneurship, workers of

this sector have been suffering from various occupational health hazards. The work-related accidents and injuries are very common particularly in the developing countries, and it costs about 5000 workers' life per day as reported by the International Labour Organization.[8] The aim of the work was to find the occupational risk factors present at the working places and associated WMSDs among the workers of textile yarn dyeing units of Nadia district, West Bengal, India.

MATERIALS AND METHODS

Study Area

Shantipur and Phulia in the district of Nadia, West Bengal, were selected for our present study. Both places are known for superfine traditional weaving sarees and other textile products where most of the local people are engaged directly or indirectly in weaving and its associated occupations.

Subject Selection

Nearly 100 Cottage Industry based yearn dyeing units are run by private entrepreneurs or master weavers. Only 7 dyeing units belong to small-scale category (10–50 employees) and rest fall under very small scale industry (<10 employees). 31 male workers from 3 small-scale units designated as GI (Group I) and 136 male workers from 21 small-scale industries were designated as GII (Group II) and randomly selected for the present study.

Physical and Physiological Parameters

Body mass index (BMI) of the workers was computed using the following equation.[9]

$$BMI = weight/(height)^2 \quad (1)$$

Workers' blood pressure at resting state were measured (twice) by sphygmomanometer (Heine, Germany) and stethoscope (Srishti, India). Resting heart rate (HR) was also measured by bpm count method from carotid artery of the workers.

Questionnaire Preparation

A part of Nordic questionnaire consisting trouble with the locomotive organs during past 12 months is used to survey the workers' MSDS's presence in different body parts.[10] Personal details such as educational qualification, headache, eyesight or hearing problems, and fatigue along with job details such as working experience, duration of work per day, resting time, and accident details were also included in the survey sheet. The questionnaire contained objective type questions with optional multiple choice answers. The survey sheet being in English communication was made in vernacular.

Working Postures Analysis

Working postures of the subjects were recorded by video photography (Canon SX110IS, Japan). Each task at 10s interval freeze frame video and posture codes were noted. In the present study, total 399 videotape frames were analyzed.

A total of 40 main tasks, namely, scouring, bleaching, dyeing, washing, and drying (18 from GI and 22 from GII) of dyeing process were selected for posture analysis, and it was done by Ovako working posture analysis system (OWAS).[11]

Working Environmental Parameters

Dry-bulb temperature (T_a), wet-bulb temperature (T_w), dew-point temperature (T_d), and Relative Humidity (RH) inside the dyeing units were recorded by SILVA ADC Pro (Sweden) whereas illumination (L) and noise (N) were measured by lux meter (Mastech MS6610, India) and digital sound level meter (Metravi SL 4005, India), respectively.

Statistical Analysis

Statistical analysis was done using MATLAB 7.0.4.365(R14) service pack 2 and SPSS Version 3.5.

RESULTS

Table 1 shows the physical profile and physiological parameters of yarn dyeing workers. The mean age of the workers is 34.4 years and 32.3 years for GI and GII units. Mean systolic and diastolic pressure of the workers of GII dyeing units are higher than the workers of GI units. Mean resting HR of the workers is about 80 bpm for both the groups.

Table 2 shows yarn dyeing worker's job profile. Workers of GII have more than 1 and ½ h of working schedule and get 10 min

Table 1: Physical and physiological parameters of dye workers

Parameter	Mean±SD		Parameter	Mean±SD	
	GI (*n*=31)	GII (*n*=136)		GI (*n*=31)	GII (*n*=136)
Age (years)	34.4±10.6	32.3±13.2	HR (min)	80.6±7.6	80.1±12.6
Height (m)	1.63±0.06	1.63±0.11	BP (mmHg)		
Weight (kg)	56.4±10.0	55.2±9.7	SBP	127.3±14.4	130.3±15.1
BMI	21.3±3.4	20.7±3.1	DBP	77.1±9.4	78.3±10.1

BMI: Body mass index, BP: Blood pressure, DBP: Diastolic blood pressure, GI: Group I, GII: Group II, HR: Heart rate, SBP: Systolic blood pressure, SD: Standard deviation

extra lunch breaks time per day than the workers engaged in GI. Number of accidents during work is found almost double for GII workers (15.1/worker) compared to GI workers.

Working postures of yarn dyeing processes are analyzed by OWAS method, and percentage distribution of detailed codes is shown in Table 3 for both GI and GII. Most frequent pre dyeing postures of back and arm are bent forward or backward (Code 2) and both arms are below the shoulder level (Code 1) for both GI and GII whereas most frequent leg posture code is 2 for GI workers and 7 for GII workers. Load or force required for pre dyeing process is <10 kg for both units. In dyeing process, most frequent posture codes for back, arm, and leg are 2, 1, and 2 for both GI and GII, respectively. Post dyeing process shows that most frequent back posture of GI workers is straight whereas bent and twisted for workers engaged in GII. For arm and load, both units show about the same percentage distribution in posture code. Workers of GI mostly maintain standing (Score 2) positions for post dyeing activities whereas workers of GII do this process on sitting position.

Frequency distribution of OWAS AC for GI and GII is shown in Figure 1a and b. It is also seen that 3.5%, 8.7%, and 2.1% working postures of different dyeing processes are in the most severe AC 4.

A comparative study between GI and GII workers' different body parts discomfort are shown in Table 4. It is observed that the most affected body parts of the dyeing workers are lower back and shoulder. There is a significant difference between these two groups reporting upper back pain, feet pain, and elbow pain.

A comparison between small-scale and very small scale industry workers regarding MSD and educational status are presented in Table 5, and it is interesting to note that the risk of WMSDs is found very high among the illiterate workers and it gradually decreases with increasing educational level. However, workers with tertiary education level, the risk of MSDs is found higher again.

Table 2: Job details of the workers

Job parameter	Mean±SD	
	GI (*n*=31)	GII (*n*=136)
Working experience (years)	11.7±9.8	15.0±12.0
Working hours/day	8.1±1.7	9.6±1.0
Lunch break/day (min)	53.0±13.0	62.2±22.7
Number of accidents/worker	6.5±4.6	15.1±10.4

GI: Group I, GII: Group II. SD: Standard deviation

Table 3: Distribution (%) of yarn dyeing posture codes of back, arm, leg, and load

Posture code	GI			GII		
	Pre dyeing (*n*=22)	Dyeing (*n*=101)	Post dyeing (*n*=39)	Pre dyeing (*n*=28)	Dyeing (*n*=115)	Post dyeing (*n*=94)
Back						
1	1 (4.5)	29 (28.7)	17 (43.6)	0	20 (17.4)	16 (17.0)
2	12 (54.5)	52 (51.5)	12 (30.8)	15 (53.6)	50 (43.5)	25 (26.6)
3	1 (4.5)	7 (6.9)	7 (17.9)	2 (7.1)	15 (13.0)	22 (23.4)
4	8 (36.3)	13 (12.9)	3 (7.7)	11 (39.3)	30 (26.1)	31 (33.0)
Arm						
1	15 (68.2)	79 (78.2)	39 (100)	16 (57.1)	88 (76.5)	86 (91.5)
2	7 (31.8)	10 (9.9)	0	9 (32.1)	17 (14.8)	7 (7.4)
3	0	12 (11.9)	0	3 (10.7)	10 (8.7)	1 (1.1)
Leg						
1	0	5 (4.9)	0	1 (3.6)	0	66 (70.2)
2	12 (54.5)	75 (74.3)	34 (87.1)	7 (25.0)	97 (84.3)	26 (27.7)
3	0	0	0	0	0	0
4	9 (41.0)	19 (18.8)	4 (10.3)	6 (21.4)	16 (13.9)	2 (2.1)
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	1 (4.5)	2 (1.9)	1 (2.6)	14 (50.0)	2 (1.7)	0
Load						
1	20 (90.9)	97 (96)	39 (100)	28 (100)	87 (75.6)	92 (97.9)
2	2 (9.1)	3 (2.9)	0	0	27 (23.5)	2 (2.1)
3	0	1 (0.9)	0	0	1 (0.9)	0

GI: Group I, GII: Group II

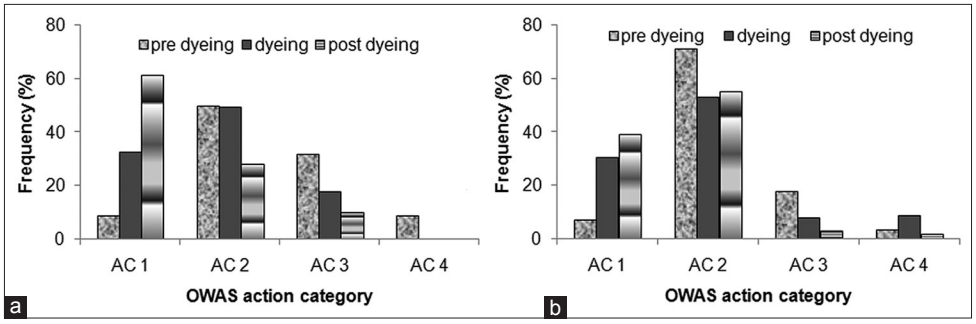

Figure 1: (a) Frequency distribution of OWAS action category of GI. (b) Frequency distribution of OWAS action category of GII. AC: Action category; OWAS: Ovako working posture analysis system

Table 4: Different body parts discomfort among GI and GII workers

Body part	RF (GI/GII)	OR	95% CI	*P*
Neck	61.3/60.3	1.04	[0.46, 2.32]	0.920
Shoulder	64.5/62.5	1.09	[0.48, 2.46]	1
Elbow	48.4/22.1	3.31	[1.46, 7.46]	0.005**
Wrist	41.9/32.4	1.51	[0.67, 3.35]	0.420
Upper back	32.3/8.8	4.92	[1.88, 12.82]	0.002**
Lower back	64.5/77.2	0.53	[0.23, 1.24]	0.214
Hip	38.7/38.9	0.98	[0.44, 2.20]	0.862
Knee	25.8/22.8	1.17	[0.47, 2.89]	0.887
Feet	38.7/14.7	3.66	[1.54, 8.69]	0.004**

GI: Group I, GII: Group II, OR: Odds ratio: $P<0.05$*; $P<0.01$**; $P<0.001$***; RF: Relative frequency (%). CI: Confidence interval

Job-related problems of GI and GII workers are shown in Table 6. It is observed that accident proneness is higher among GII workers (94%) compared to that of GI workers (83.9%).

These yarn dyeing workers also suffer from headache, eyesight, and hearing problems. Most of the workers of both units feel tired or fatigue after the daylong hard work.

Table 7 shows seasonal variations of working environmental parameters of dyeing units. It is observed that mean workplace air temperatures (T_a) range from 28.1°C–38.3°C, 28.6°C–33.1°C, and 20.8°C–25.7°C in GI units whereas 21.0°C–39.7°C, 23.0°C–36.4°C, and 20.4°C–30.9°C in GII units during summer, monsoon, and winter months, respectively. RH is also found very high during monsoon season in both sectors. Mean illumination levels are found 66.2 lx and 147.4 lx for GI and GII units, respectively. A very high noise level (91.2 ± 5.1 dB[A]) is also recorded when the high noisy machine called "hydro structure" is used for drying yarns in the GI units.

DISCUSSION

Textile industry is one of the most hazardous industries at present. Workers engaged in this sector are exposed to different types of hazardous working conditions daily. The dye workers are doing 8–10 h of heavy and strenuous work per day without any proper work-rest cycle. According to the World Health Organization,[12] mean BMI of the dye workers are found in the normal category.

The results of the present study have shown that WMSDs are very common among these unorganized textile dyeing workers. The study identified that pre dyeing job is the most strenuous and harmful (according to AC 3 and AC 4) for the musculoskeletal system of the workers. The results of the study have also found out that bent and twisted back with squatting knees postures are involved as the main risk factor for pre dyeing activities. The second most harmful job that has been identified by the study is dyeing activity with bent and twisted back, uncomfortable arm, and squatting knees positions. It is also observed that all the strenuous postures into the AC 3 and AC 4 of post dyeing jobs are due to bent and twisted back and poor arm positions. During the pre-dyeing, dyeing, and the post dyeing activities, workers sustained different postures ranges from 30 s to 130 s, 40 s to 190 s, and 30 s to 340 s, respectively. As the complete yarn dyeing process is constantly repetitive in nature, every worker has to do the entire process repetitively for more than 4 h. It is found from the study that most of the textile yarn dyeing workers suffer from musculoskeletal problems in various body regions due to the maintenance of different awkward working postures repeatedly. Several studies have reported that repetitive work with long working hours and poor working postures may cause MSD among the workers.[13,14] Some researchers have shown that forward bending and twisting of the back can exert compressive forces on spine and back muscle which may lead to lower back pain. From the present observation, it is also noticed that most of the subjects under study have been suffering from lower back pain due to bent and twisted back postures which increase the cumulative load on lumber region. The association between the awkward body postures and WMSDs has been reported by other investigators from time to time.[15-18] It is clear from the OWAS analysis that, forward or backward bent back position, arms above shoulder level and standing on one straight leg for a long time are also responsible for developing WMSDs among the yarn dyeing workers.

Farioli *et al*.[19] have reported that prevalence of musculoskeletal pain is found high among the low educated persons. It is observed in our study that the risk of MSDs is high for both workers of illiterate group and tertiary level of education. For the first case lack of proper knowledge is responsible whereas, for the workers of tertiary level of education, complete negligence is the cause of MSDs.

Rao and Lundgren.[20] have mentioned that 20.5°C–26.6°C is the correct comfort zone temperature for India whereas Tanakam[21] has reported that 21°C–25°C is the suitable workplace temperature with 40–60% RH. In our case, we have found that workplace temperature is higher than the recommended level in both dyeing units except winter. RH inside the dyeing units is also found high in winter months and reach more than 85% during monsoon months. Many researchers have reported that hot and humid working environments can lead to severe discomfort and mental stress among the workers that may increase accident rate in workplaces.[22] In the present study, a number of accidents have been reported by the workers and also found very high, maybe, due to uncomfortable working conditions and psychological stresses.

Table 5: Association between MSD and education among GI and GII workers

Educational status	RF (GI/GII)	OR	95% CI	*P*
Illiterate	29.0/24.3	3.07	[0.57, 17.31]	0.474
Primary	16.1/18.4	2.60	[0.31, 21.89]	0.551
Secondary	41.9/52.2	1.84	[0.46, 7.61]	0.467
Tertiary	12.9/5.1	2.84	[0.15, 53.52]	0.760

GI: Group I, GII: Group II, OR: Odds ratio, RF: Relative frequency (%). MSD: Musculoskeletal disorders

Table 6: Comparison of job-related problems between the two groups

Factor	RF (GI/GII)	OR	95% CI	*P*
Accidents	83.9/94.1	0.32	[0.09, 1.07]	0.067
Headache	58.1/51.5	1.30	[0.59, 2.87]	0.639
Eye sight problem	54.8/35.3	2.22	[1.01, 4.90]	0.070
Hearing problem	16.1/10.3	1.67	[0.55, 5.06]	0.532
Feeling tired	83.9/86.8	0.79	[0.26, 2.33]	0.772

GI: Group I, GII: Group II, OR: Odds ratio, RF: Relative frequency (%). CI: Confidence interval

Noise levels are found under the occupational exposure limits in both sectors.[23] Hearing problems are found higher among GI workers compared to that of GII workers. It may be due to use of high noisy machine (hydro structure) in the yarn drying process in GI units. It is interesting to note that illumination level is very low in the GI workplaces compared to that of GII workplaces. GII units which are cottage based built with a roof on four supporting pillars without any surrounding walls but on the other side, GI units are well-constructed concrete building surrounded by walls which prevent natural light from penetrating into the working zone, and it is the main reason that GI sectors have less illumination. It may be the reason that more than half of total working persons of GI are suffering from frequent headache and eyesight problems.

Due to strenuous work, prolonged working hours, uncomfortable working conditions (high temperature and humidity), wrong working postures, most of the workers feel very tired or fatigue after the work. Adequate fluid intake and air circulation in the working places, thermal comfortability can be maintained during summer and monsoon seasons.[24]

The present study has shown the occupational risk factors present in the unorganized textile yarn dyeing sectors despite having some limitations. The difficulty in obtaining a large number of samples from the study area imposes limits on the data interpretation. Another limitation of the survey is that the accident data are obtained from the self-report of the subjects as there were no systems of maintaining accident register.

CONCLUSIONS

Most of the yarn dyeing workers suffer from WMSDs particularly at the lower back, shoulder, and neck regions due to the prolonged maintenance of awkward working postures. Illiterate workers are found more prone to such WMSDs. Higher accidents rates, headache, and eyesight problems are observed among the workers may be due to uncomfortable working condition, excessive psychological stresses and lack

Table 7: Different environmental parameters of dyeing units

Environmental parameter	GI (*n*=3)			GII (*n*=21)		
	Summer	Monsoon	Winter	Summer	Monsoon	Winter
Ta (°C)	34.1±2.6	30.5±1.5	23.5±1.3	35.1±3.2	29.4±3.4	24.4±1.8
Tw (°C)	27.3±3.3	28.4±0.7	18.4±1.0	27.2±3.4	27.2±2.7	19.3±2.2
Td (°C)	25.0±4.6	27.8±0.6	15.4±0.6	24.0±3.9	26.5±2.6	16.3±3.3
RH (%)	59.9±8.3	85.4±5.1	60.2±4.1	54.0±10.1	88.7±5.1	61.3±11.5
L (lx)	44.3±34.9	72.3±64.8	82.2±75.4	122.1±81.1	181.1±161.8	139.1±95.3
N (dB (A))	74.1±11.6	74.4±10.6	73.4±5.6	60.5±8.8	63.0±5.5	63.9±13.6

GI: Group I, GII: Group II, L: Illumination, N: Noise, OR: Odds ratio, RH: Relative humidity, Td: Dew-point temperature, Ta: Dry-bulb temperature, Tw: Wet-bulb temperature

of use of modern machineries. Use of personal protective equipment, suitable working environment, correct working postures, and routine health check-up may help reduce the accident rates in working places and others associated with health hazards of the yarn dyeing workers.

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