Examination of postures and frequency of musculoskeletal disorders among manual workers in Calcutta, India

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Background: Manual material handling (MMH) activities require workers to adopt various awkward postures leading to the development of musculoskeletal disorders (MSD).
Objectives: To investigate the postures adopted during heavy load handling and the frequency of MSDs among MMH workers in Calcutta, India.
Methods: We conducted a cross-sectional study with 100 MMH workers. MSD frequency was assessed via the Standardized Nordic Questionnaire. The Ovako Working Posture Assessment System (OWAS) was used to analyze working posture. We used logistic regression to predict MSD risk factors.
Results: Ninety five percent of workers reported a MSD in at least one body part in the past 12 months. According to OWAS results, 83% of the analysed work postures require immediate corrective measures for worker safety. The most harmful posture was carrying a heavy load overhead. Carrying more than 120 kg increased the odds of low back and neck pain by 4.527 and 4.555, respectively.
Conclusions: This sample had a high frequency of reported MSDs, likely attributed to physiologically strenuous occupational activities repeated on average of 30–40 times daily. Ergonomic interventions, such as the use of handcarts, and occupational training are urgently needed.

Keywords: Musculoskeletal disorder, Informal sector, Manual material handling, OWAS, Nordic musculoskeletal questionnaire

Introduction

Musculoskeletal disorders are injuries affecting muscles, bones, tendons, ligaments, and cartilage. Work-related musculoskeletal disorders (WMSDs) are multi-factorial in nature. Epidemiological studies have found an association between WMSDs and heavy load lifting, forceful exertion, awkward posture, repetition, and whole body vibration.[1] WMSDs result in disability, lost work time, and increased production costs.[2] They rank first among the health problems in the frequency with which they affect quality of life.[3] In the United States, approximately 29% of absentee causing workplace injuries are due to WMSDs.[4] In Great Britain, a person with a WMSD was absent from work an average of 15 days in 2013–2014.[5] WMSDs result not only in poor health, but also contribute to individual, employer, and societal costs.

WMSDs are common with tasks that involve Manual Materials Handling (MMH) and heavy physical workloads.[8, 9] MMH tasks, when performed repeatedly or over long periods of time, can lead to fatigue, pain, and/or injury. Frequent awkward postures, repetitive motions, and forceful exertions (carrying or lifting heavy loads) are risk factors for injuries related to MMH activities.[10–12]

The 2007–2008 Economic Survey of India reported that 93% of the Indian workforce is directly engaged with informal sector and 98% of employers in the country are employed in the informal sector, accounting for 53.9% of India's gross domestic product (GDP).[13–15] MMH tasks are frequent in the informal sector and expose workers to physical risk factors.[10] Work postures influence the development of MSDs, with awkward postures associated with a higher risk of MSD development.[12, 16–18, 20] Kilbom reported that workers with forward flexion of the neck and raised arms had a higher risk of MSDs than those not performing these movements.[21]

Calcutta's central market is open 24 h a day, 7 days a week, and approximately 300 manual workers are continually transporting produce from wholesalers to sellers, primarily by placing heavy loads on their heads. These tasks pose a risk of injury and development of MSDs.[7,22,23]

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While lifting activities are associated with MSDs, researchers typically focus on lifting technique and weight of the load in determining the onset of MSDs.[24, 25] Previous studies have not included heavy load handling or overhead load lifting by workers. We investigate the postures adopted during heavy load handling and overhead lifting among workers in Calcutta's (India) central market and document the frequency of MSD among our sample.

Methods

Study design

This was cross-sectional study carried out with 100 workers in Calcutta's central market between March and May of 2013.

Participants

One hundred manual material handling (MMH) workers were selected from the central market area in Calcutta. Workers were approached by the study authors and asked to participate, assessed for eligibility, and explained the study protocol in their native language. Inclusion criterion for participation was at least five years of work experience in a MMH occupation. Written consent of all participants was obtained prior to their inclusion in the study. The protocol and procedures employed in this study were in accordance with the Ethical Guidelines for biomedical research on human subjects of Indian Council of Medical Research.[26] Ethical clearance was obtained from the Institutional Human Ethical committee of The University of Calcutta.

Data collection

The authors administered questionnaires in one-on-one interviews with participants. Worker's physical measurements were recorded post-interview. Work movements performed by each participant were video recorded one time. The video recording was done for the complete work cycle beginning with lifting the load overhead to lowering the load. Load weight was also measured and recorded.

Measurement of physical parameters

Participant height and weight were measured by an anthropometer (Martin's Anthropometer) and "Crown" weighing machine (Mfg. by Raymon Surgical Co.). The body mass index (BMI) of all the subjects was calculated based on height and weight measurements.[27, 28]

Musculoskeletal disorder

The Standardized Nordic Questionnaire was used to assess the frequency of MSD among study participants.[29] This is a subjective questionnaire with questions about work organization and behavior, work stress, and musculoskeletal disorders. Several questions, including "What is the nature of your job?" "What is your current salary?" "How many hours do you work daily?" and "How many times do you lift a load daily?" were added to suite the context of this study. Pain intensity and discomfort were measured using the Body Parts Discomfort (BPD) scale, which rates pain and discomfort on a scale from 1 to 10.[30]

Posture assessment

Common lifting postures were assessed using the Ovako working posture assessment System (OWAS).[31] OWAS identifies the most common work postures for the back (four postures), arms (three postures), and legs (seven postures), and the weight of the load handled (three categories) and indicates whether postures are ideal or if there is a need for corrective measures. Final OWAS scores are divided into four categories: Category 1: no corrective measures required; Category 2: corrective measures required in the near future; Category 3: corrective measures required as soon as possible; and Category 4: corrective measures required immediately.

Measurement of physiological parameters

Physiological parameters were measured using the Bio Harness instrument (Make: Zephyr, Zephyr Technology, New Zealand). This device assesses stress using physiologic measurements including heart rate, breathing rate, and skin temperature. The device was mounted on the chest of participants immediately preceding work and removed after load lifting was complete.

Data analyses

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS v. 20). Workers were divided into three groups based on work experience: 5–14 years of experience (group I), 15–24 years of experience (group II), and 24+ years of experience (group III). One-way ANOVA was used to investigate significant differences in demographic characteristics and mean BPD scale scores among the three groups. The physiological parameters (heart rate, respiratory rate, and skin temperature) data violated the assumption of normality and therefore the Friedman Test (nonparametric alternative of one-way repeated measure ANOVA) was used to test for significant differences in these physiological parameters during the three different work activities (lifting, carrying, and lowering). A *post hoc* test was performed using the Wilcoxon signed rank test to determine where the significant difference occurred between groups. To assess the association between MSDs and load handled, binary logistic regression models were used, with a P-value of ≤ 0.05 indicating significance.

Results

Participants

Demographic characteristics of the sample are presented in Table 1. Workers were divided into three groups based on work experience: 5–14 years of experience (group I), 15–24 years of experience (group II), and 25 years or more

Table 1 Worker demographics (n = 100)

	Work experience in manual material handling job			
	5–14 years (*n*=38)	15–24 years (*n*=31)	25 years and more (*n*=31)	P value
Age (years)	27.5 ± 3.7	37.4 ± 4.9	45.6 ± 6.7	<0.05
Height (cm)	163.7 ± 5.9	164.1 ± 7.0	163.1 ± 5.8	0.79
Weight (kg)	61.6 ± 8.4	62.2 ± 7.4	62.9 ± 10.0	0.84
BMI (kg m^{-2})	22.1 ± 2.1	22.0 ± 2.6	23.1 ± 3.2	0.23
Frequency of Lifting	34.5 ± 11.2	32.3 ± 9.2	28.2 ± 9.4	0.03
Experience (Years)	18.2 ± 9.1*			
Regular working hours per day	9.2 ± 2.8**			

Note: Values are expressed as mean ± standard deviation.
*Mean work experience of all workers (*n* = 100).
**Mean working hours of all workers (*n* = 100).

experience (group III). A significant difference ($P < 0.05$) was observed in lifting frequency between Group I and III.

Work activities

The workers in this central market carry baskets of produce above their heads from the trucks or trolleys into the market. Baskets weigh between 100 and 550 kg. Lighter baskets (~100 kg) are carried by individual workers, and heavier baskets are carried by two to five workers. On average, each worker carries a load of approximately 100 kg overhead. The work can be divided into the following phases:

(1) *Lifting*: Depending on the size and weight of the load, about 10–15 workers, lift the load over the heads of the workers who will carry that load. This phase consists of repeated jerking of the trunk and legs. The postures adopted by the workers during lifting are awkward and involve frequent bending and twisting.
(2) *Carrying*: Load is carried overhead. While walking with load, the workers maintain a stiff neck with no allowance for head rotation. They walk with the load overhead for an average distance of 800 m.
(3) *Lowering*: In this phase, the workers bend and/or twist their back to unload the baskets.

The lifting, carrying, or lowering of the load is done manually without the aid of mechanical equipment. Figure 1 depicts the work process.

Musculoskeletal disorder

Figure 2 reports the percentage of workers reporting pain by body parts in the last 12 months. The mean BPD scale scores and the results of the one-way ANOVA are presented in Table 2.

Posture analysis

Work process analysis found that the workers were using maximum effort in lifting the load. The lifting process required the work of 10–15 people simultaneously. Load lifting required that workers perform awkward postures involving repetitive jerking and twisting of the trunk and lower back. The lifting activity was divided into three parts: (1) lifting the load from ground to waist height; (2) lifting the load from waist height to chest height; and (3) lifting the load from chest height to above the head. These phases of lifting were identified and analyzed using the video recordings.

Five hundred postures were sampled from the video recordings. Table 3 presents the results of the OWAS posture analysis. OWAS action category 3 (corrective measures required as soon as possible) had the most number of postures (47.6%), followed by OWAS action category 4 (corrective measures required immediately) (35.2%). Only 10% of the postures fell into action category 1 (no corrective measures required). Table 4 displays the dominant postures during different work activities along with the corresponding OWAS codes. Figure 3 shows the number of postures in different OWAS action categories for the three lifting phases. The mean lifting time was found to be 1.3 ± 0.46 s, 2.8 ± 0.73 s and 4.6 ± 0.98 s for ground to waist level lifting, waist to chest level lifting, and chest level to overhead lifting respectively. The final phase of the lifting was the most time-consuming and around 60% of the postures in this phase fell into OWAS action category 4.

Physiological parameters

Table 5 shows the results of the Friedman Test, which indicate that physiological parameters differed significantly by activity. Post hoc tests revealed that the heart rate during lifting varied significantly ($P < 0.05$) with carrying and lowering the load. For respiratory rate and skin temperatures, there was no significant difference between lifting and carrying, but the parameters differed significantly between carrying and lowering and lifting and lowering ($P < 0.05$).

Heavy load and musculoskeletal disorder

Results of the binary logistic regression are presented in Table 6. Presence of pain symptoms were entered in the regression model as dummy dependent variables. Load was grouped into three categories: 80–99, 100–119, and 120 kg or more. This variable, along with frequency of lifting and total time of lifting, were included as independent variables. An interaction term of lifting frequency and lifting time was entered as a predictor.

Figure 1 Load lifting by the MMH workers of central market in Calcutta. *a* The workers are ready with the load; *b* many workers together lift the load. This phase involves adoption harmful postures; *c* the workers are ready with the load; *d* four workers carry this load overhead.

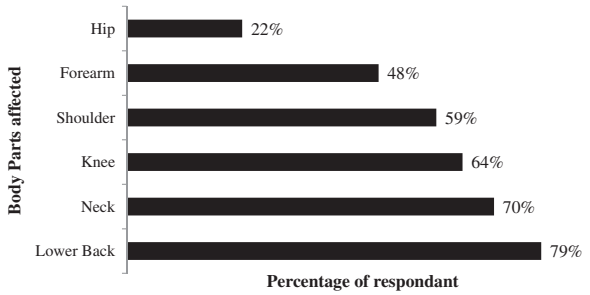

Figure 2 Prevalence of musculoskeletal disorders in different body parts.

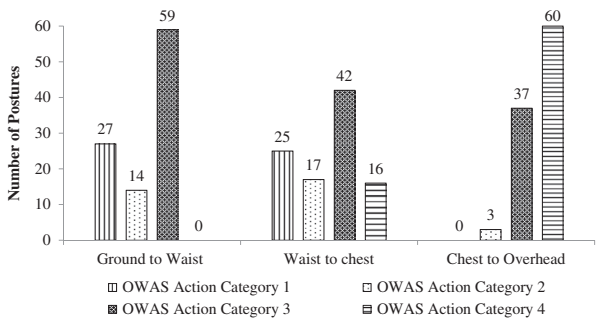

Figure 3 OWAS action categories for three phases of lifting task.

Discussion

We found a high frequency of MSDs among the manual workers in Calcutta's central market. Approximately, 95% reported experiencing MSD symptoms in the last 12 months in any body part. Lower back pain was most common, followed by pain in the neck, knee, and shoulder. This high frequency of MSDs can be attributed regular lifting of heavy loads. Datta et al. concluded from their studies on carrying load overhead that the maximum permissible load for an eastern Indian male worker was no more than 30 kg.[32] We found male workers carrying approximately 100 kg overhead for a distance of about 800 meters. The severity of this activity is enhanced as the task is performed repetitively, an average of 32 times daily. The National Institute of Occupational Safety and Health (NIOSH), in a review of work related to MSDs, found strong evidence that low back disorders are related to forceful lifting and to the weight of load lifted.[1] Most workers reported that feelings of pain/discomfort interfere with their work. This is in line with our results that average lifting frequency is reduced significantly in the group III (24+ years work experience) compared to groups I and II (Table 1).

Table 2 The mean pain intensity (BPD scale ratings) of the workers

	Work experience in manual material handling job				
	5–14 years ($n=38$)	15–24 years ($n=31$)	>25 years ($n=31$)	*F* value	P value
Lower back	4.03 ± 2.775	6.13 ± 3.394	6.55 ± 3.424	6.356	<0.05
Neck	3.03 ± 2.520	4.65 ± 3.136	4.97 ± 3.478	4.142	0.02
Shoulder	1.82 ± 2.091	3.68 ± 3.081	4.06 ± 3.386	6.406	<0.05
Knee	2.82 ± 2 .827	5.00 ± 3.531	5.48 ± 3.687	6.249	<0.05

Note:
Values are expressed as mean ± standard deviation.

Table 3 Postures by OWAS action categories

OWAS action category	OWAS codes	No. of sampled postures
No corrective measures required	1	52 (10.4%)
Corrective measures required in near future	2	34 (6.8%)
Corrective measures required as soon as possible	3	238 (47.6%)
Corrective measures required immediately	4	176 (35.2%)

Table 4 OWAS analysis during different activities

Serial no.	Task	Stick diagram	OWAS codes	OWAS action category
1	Lifting (from ground to waist level)		2,1,2,3	**3:** Corrective measures are needed as soon as possible
2	Lifting (from waist level to chest level)		1,1,3,3	**1:** No corrective measure required
3	Lifting (from chest level to above the head)		2,2,4,3	**4:** Corrective measures required immediately
4	Carrying the load		2,3,7,3	**4:** Corrective measures required immediately
5	Lowering the load from overhead to ground		2,2,3,3	**3:** Corrective measures are needed as soon as possible

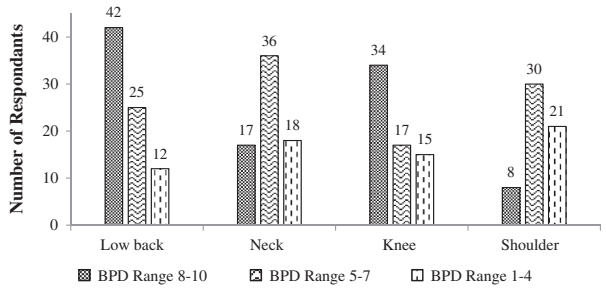

Figure 4 BPD scale ratings of the pain symptoms in different body parts.

The results of the BPD scale showed that the severity of low back pain was higher compared to other body parts (Figure 4). Fifty-four percent of people with low back pain symptoms reported a BPD scale rating between 8 and 10, while the same BPD scale rating (8–10) was reported by 14, 24 and 52% people for shoulder, neck and knee, respectively. We also found that the mean BPD scale score increased as the worker group increased (Table 2), supporting the hypothesis that MSD symptoms are aggravated over time as they remain untreated.

Table 5 Physiological data of the workers during different activities (n = 100)

Activities		Heart rate (bpm)	Respiratory rate (min^{-1})	Skin temperature (°C)
Lifting	Mean ± SD	124.6 ± 18.3	24.9± 9.9	33.6± 1.2
	50th Percentile	120.2	22.9	33.7
Carrying	Mean ± SD	132.4 ± 14.3	26.0 ± 6.6	33.6± 1.6
	50th Percentile	128.2	24.2	33.8
Lowering	Mean ± SD	131.7± 16.9	27.7± 6.6	33.7± 1.8
	50th Percentile	126.7	26.7	34.1
Friedman Test	χ^2 Statistics	45.5	21.0	23.0
	P value	<0.001	<0.001	<0.001

Table 6 Association of low back and neck pain with weight of the load and lifting frequency

							95% CI for OR	
Variable	B	SE	Wald	df	Sig. level	OR	Lower	Upper
(A) Low back pain								
Age	–0.021	0.030	0.482	1	0.48	0.980	0.924	1.038
80–99 kg Load			5.999	2	0.05			
100–119 kg Load	1.167	0.677	2.969	1	0.08	3.213	0.852	12.120
>120 kg Load	1.510	0.644	5.505	1	0.01	4.527	1.282	15.981
Lifting frequency	–0.116	0.051	5.257	1	0.02	0.890	0.806	0.983
Lifting frequency × Lifting time	0.011	0.006	3.740	1	0.05	1.012	1.000	1.023
Constant	1.796	1.543	1.355	1	0.24	6.024		
(B) Neck pain								
Age	–0.001	0.027	.000	1	0.98	0.999	0.949	1.053
80–99 kg Load			7.967	2	0.01			
100–119 kg Load	1.219	0.605	4.067	1	0.04	3.384	1.035	11.066
>120 kg Load	1.516	0.556	7.437	1	<0.05	4.555	1.532	13.543
Lifting frequency	–0.019	0.046	0.172	1	0.67	0.981	0.896	1.074
Lifting frequency × Lifting time	0.003	0.005	0.336	1	0.56	1.003	0.993	1.013
Constant	–0.287	1.354	0.045	1	0.83	0.750		

OWAS analysis revealed that 83% of the postures are in the OWAS action category 3 and 4, requiring urgent corrective measures. During load lifting, there are repeated jerk movements of the trunk and legs in addition to twisting and bending of body parts. Heavy loads and distances of approximately 800 meters result in a high risk of MSD development in the neck, lower back, and lower limbs. Carrying the load overhead emerged as the most harmful activity, in terms of posture adopted, with 100% of the postures falling in the OWAS action category 4 (corrective measures required immediately). It is well documented that awkward posture is one of the risk factors for the development of MSDs.[33–37] The OWAS method has been successfully applied in many industries, including construction,[38] shipping,[39] and liquid petroleum gas workers.[40] The high percentage of unsafe postures is likely a cause of the high frequency of MSDs. Although load lowering includes postures in OWAS action category 3, this phase was less hazardous due to the short duration. This conclusion is based on similar results in different unorganized sectors including foundry,[41] sand core making,[42] and stone carving workers.[43].

The results of the posture analysis are in line with the findings from the physiological parameters measurements. The mean and median heart rate data suggests that the workers have maximum heart rate during carrying and lowering of the load. The *post hoc* analysis shows that heart rate during walking with load and lowering was significantly higher than load lifting. A significant difference was observed between carrying and lowering and between lifting and lowering for respiratory rate and the skin temperature data. These results depict the increasing physiological stress developed during the course of a single cycle of manual handling of heavy load by the workers.

The results of the logistic regression depict the relationship of load carried with development of MSD. The odds of having low back pain and neck pain increases by 4.527 times and 4.555 times, respectively, when the load is 120 kg or more compared to when the load carried is between 80 and 99 kg. Increasing lifting frequency and duration of lifting was significantly associated with an increased likelihood of experiencing low back pain.

We found that walking with heavy overhead loads was the most hazardous posture and had the longest duration compared to other activities performed by workers. These activities pose serious threats not only in terms of awkward posture but also physiological stress generation.

This study showed that load weight increased the odds of having MSD. The most hazardous postures (OWAS action categories 3 and 4) occurred during twisting and bending of trunk and leg during overhead load lifting. The primary aim of intervention studies should be to reduce the weight of the load. It is also recommended that instead of overhead lifting, the porters use wheelbarrows to move products. This will reduce the hazards of heavy load lifting and carriage.

Moreover, education with the workers about proper techniques for safe lifting and strengthening exercises to reduce pain may reduce MSDs in this population.

This study has limitations, including a small sample size ($n = 100$). However, our results are in agreement with larger studies in different populations. The study was performed in only one market, but it is likely that manual workers in other markets in India and elsewhere are performing similar activities. Barring these limitations, this study depicts the dismal scenario of the heavy load-handling workers of the central market area in Calcutta. These workers are highly prone to MSDs because of the heaviness of the load they carry overhead and the adoption of harmful postures during lifting of the same load overhead. Ergonomics interventions are urgently needed to improve the health of these workers.

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