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RESEARCH ARTICLE

PRE-MAPPING OF POTENTIAL RISKS IN WORK PLACE ENVIRONMENT AND ASSESSMENT OF RISK OF LOW BACK DISORDERS WITH REPEATED LIFTING IN FLOUR MILL WORKERS IN MUMBAI

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ABSTRACT

Background: The flour mill workers work in a very unhygienic environment for 6-8 hours a day and perform a duty of loading and unloading a plastic bags or boxes or sacks of flour into the mill. The job demands a high intensity of physical strength.
Material and Method: A sample 100 Flour mill workers at Thane and Chembur were surveyed for the potential risk for (work related musculoskeletal disorders) WRMD's and hazards of work environment using a Pre-Mapping assessment tool provided by EPM. Work related hazards were used to assess the qualitative risk of biomechanical overload of manual handling, pollutants and repetitive movements. Quantitative analysis of risk of work related musculoskeletal disorder was assessed using NIOSH Lifting Equation.
Results: This research aimed to preliminarily assess the risk of biomechanical overload of activity in flour mill workers using the EPM pre-mapping tool. Flour Mill workers do work in extreme awkward postures at their workplace which makes them vulnerable to health hazards they have high risk of being inflicted with Low back injuries (Spine), either cumulative or acute in nature. SPSS version 14 was used to analyse the data. Frequency tables and percentile values were computed from the collected data. On Pre-mapping of priorities for biomechanical overload from EPM (Ergonomic of posture and movement) it was observed that 100 % of the workers were subjected to repetitive movements, continuous lifting of heavy objects, had issues with climatic conditions and pollutants. Also 100 % of the workers faced vibration at work place. 94 % of the workers exhibited a high level of risk with Biomechanical overload- load of manual transport. When assessed for biomechanical overload for spine and lower limb awkward posture, 50% and 47% of workers fell in the High and Very High level of risk factors respectively i.e., postures having a very harmful effect on musculoskeletal system for which corrective action should be done as soon as possible. Environmental factors like working in poor lighting, noisy environment and particulate (flour) pollutants did increase the risk of work related health disorders. NIOSH lifting equation showed High Measures of Lifting index in 69 mill workers indicating that flour mill workers work at High level of risk of acquiring low back problems-which may expose a significant proportion of the working population to risk of injury. A prompt action is needed to rectify their postures to prevent WRMDs.
Conclusion: Pre-mapping of potential risks of WMSDs show that the workplace environment comprising poor lighting, vibrations, microclimatic conditions and pollutants (flour dust) affect the working conditions negatively. NIOSH equations denote high lifting indices making it evident that the Lifting index and the load lifted by the flour mill workers in the flour mills are the highest risk factors in the job demands of flour mill workers which could lead WMSD's. The results suggest that the tasks should be redesigned ergonomically to eliminate the risk factors that may cause low back injuries.

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INTRODUCTION

Ergonomic evaluation in industrial settings has recently received increased attention. Jeffress (1999) indicated that approximately 650,000 workers every year suffer serious injuries and illnesses caused by overexertion, repetition, and other types of physical stress. The term "WRMD's" refers to work related musculoskeletal disorders; which imply (John *et al.,* 2006) musculoskeletal disorder to which the work environment and the performance of work contribute significantly, or (Richard, 1983) musculoskeletal disorder that are made worse or longer lasting by work condition. These work place risk factors, along with personal characteristics (Eg:- physical limitation or existing health problems) and societal factors, are thought to contribute to the development of WRMD's (Armstrong *et al.,* 1993) they also reduce worker productivity or cause worker dissatisfaction. These risk factors are :- 1. Awkward posture (e.g. - Bending and Twisting), 2. Repetitive motion (e.g. - Frequent pushing pulling, carrying

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and lifting), 3. Forceful exertion (e.g. - Carrying or lifting heavy load), 4. Pressure points (e.g. - Grasping loads) and 5. Vibration and Heat Repeated exposure to one or more of this factor may initially lead to fatigue and discomfort. Overtime injury to the back, shoulder, hand, wrist or other parts of the body may (van der Beek *et al.,* 1999). Injuries can include damage to the muscles, tendons, ligaments, nerves, and blood vessels (NIOSH, 1997). Repetitive high exertion lifting is a major contributor to injuries of low back (Resnick and Chaffin, 1997**)**. The level of risk depends on the intensity, frequency and duration of the exposure to these condition and the individual's capacity to meet the force or other job demands that might be involved. This condition are more correctly called "Ergonomic Risk Factors for Musculoskeletal Disorders"

The Occupational Safety and Health Act, signed by President Richard M. Nixon, on December 29, 1970, created both NIOSH and the Occupational Safety and Health Administration (OSHA). In 1981, the National Institute for Occupational Safety and Health (NIOSH) recognized the need for increased attention in work-related back injuries and published the Work Practices Guide for Manual Lifting. A revision of manual lifting practices was published in 1991 entitled Scientific Support Documentation for the Revised 1991 NIOSH Lifting Equation. A final lifting equation was published as the Revised NIOSH Equation for the Design and Evaluation of Manual Lifting Tasks in 1993. The revised NIOSH equation is primarily concerned with the application of ergonomic measurements and equations for the protection of workers employed in a wide range of lifting tasks. As the number of work-related musculoskeletal disorders (WMSDs) increase and scientific evidence validating intervention programs, OSHA has taken recent action to draft a national ergonomic regulation (National Research Council, 1999).

Revised NIOSH Lifting Equation is a tool for assessing two-handed manual lifting and is an inexpensive and very useful methodology (Maria *et al.,* 2009). Fire brick manufacturing company with a high prevalence of low back injuries was selected for analysis of lifting tasks using revised NIOSH lifting equations (Min, *et al.,* 1999). Sagittal lifting tasks are an exception rather than the rule in many industrial settings (Patrick, 2003). Peak dynamic bending moments was quantified on the spine during sagittal plane lifting as a function of the load's initial height above the floor, the load's magnitude, and the lifting speed (Steven *et al.,* 1996). Load constant obtained in this investigation was about the same as the one recommended in the NIOSH equation, which means that young, healthy, Korean males are well protected by the NIOSH equation (Kwan, *et al.,* 2006). In a study by Dennis and Spinal loads during two-person lifting tasks performed with team members of matched versus unmatched standing height were compared and dynamic L4/L5 torque was calculated to estimate L4/L5 compression and shear forces. No significant differences were found in the maximum torque, compression or shear forces at L4/L5 However, the larger spinal load incurred by the tall subjects at the end of the unmatched compared to matched lifts and they were only one-third of the maximal spinal load that occurred during the lift and were below the NIOSH Action Limit (Dennisand, 2003). The effects of frequency on maximum acceptable weights (MAWs) of lifting and the effects of extended horizontal reach lifting (hand distance, 48 cm from chest) on MAWs were studied. MAWs of lifting with the large box was significantly affected by frequency which verifies the extreme effects of lifting with an extended horizontal reach and quantified the effects of the 20 lifts/min lifting frequency (Vincent, 2010). The purpose of this study was to identify the Potential Risks in Work Place Environment and assess risk of low back disorders with repeated lifting in Flour Mill Workers in Mumbai. Pre-Mapping of Work Related Hazards was conducted to identify the risk of acquiring WRMSDs. In the present study, we assessed the risk of low back problems while loading and unloading the plastic bags and dabbas / boxes or sacks using NIOSH (National Institute of Occupational Safety and Health) Lifting Equation.

Flour mill workers

The flour mill workers work in a very unhygienic environment for 6-8 hours a day and they have a duty of loading and unloading a plastic bags boxes or sacks into the mill. Different posture and workplace environment of the flour mill were analyzed by using a NIOSH scale (Lifting Index and Pre-mapping of work related hazards) and assessment was done by videotaping. The job demands a high intensity of physical strength. They are exposed to unhygienic workplace environment and high level of physical demands which make them vulnerable to musculoskeletal injuries and pulmonary and respiratory disease over a long period of time.

Job-analysis

They have to work for 6-8 hours in a day in a environment of excessive exposure to fine organic dust. They have to mill the Wheat, Rice, Maize etc

Task-analysis

Their work comprises of lifting the bags from the shoulder level and unloading into the miller machine, bending from trunk and loading the plastic bags and carrying and transport to some distance or by pushing to place nearby machine to place the bags and steel/aluminium/plastic boxes on a desk or floor.

Job demands

Their job demands a high amount of physical activity and unhygienic environment of work place which leads to a great amount of postural impairments and pulmonary and respiratory problems respectively. Thus purpose of the present research was to find the awkward postures and workplace environment risk factors that could cause low back discomfort to flour mill workers. The following pictures in Figure. 1 show the working conditions, the work environment and the postures adopted at work place. A flour mill worker with a high prevalence of low back injuries was selected for analysis of lifting tasks using the NIOSH lifting equations. We analyzed several manufacturing processes: loading, un-loading and packing processes involving frequent lifting and lowering in asymmetric postures. Majority of the lifting tasks in the flour mill workers exceeded the recommended weight limit (RWL). Most of the jobs under study could be redesigned to lessen the biomechanical stress simply by making horizontal locations closer to a worker or by reducing the asymmetric angles.

Figure 1. Working conditions, the work environment and the postures adopted at work place of flour mill workers

Figure shows that the worker has to het the boxes from a shelf singlehandedly, adopt awkward postures and there is very little space to move about in the work area.

Relevance to industry

During flour milling processes, asymmetric lifting activities are frequently performed in many areas of Mumbai. It is crucial and beneficial to both government and labour to evaluate such tasks ergonomically based on the NOISH lifting equations for identifying risk factors that may cause musculoskeletal disorders.

MATERIALS AND METHODS

Hundred Flour mill workers from many areas in Mumbai volunteered to participate in the study and gave written consent for the same. The Ethics Committee of D.Y.Patil University sanctioned the research protocol to be conducted. Workers working in the flour mill for 1 year and more were considered for the study. The subjects required to be neurologically physically fit to be included in the study. The subjects were interviewed for collecting demographic characteristics via the pre-mapping software. Other determinants of the pre-mapping tool were also observed and marked accordingly. Subjects were clothed normal routine traditional dress wore at their workplace.

Application Manual for Revised NIOSH Lifting Equation: http://www.cdc.gov/niosh/docs/94-110/ and worksheet from http://personal.health.usf.edu/tbernard/HollowHills/NIOSHWPGM11.pdf , a measure tape was used to take the distance, a weigh scale to measure the weight of the objects being handled or lifted and a goniometer was required to measure the angle of asymmetry to assess the various variables included in NIOSH tool. Thereafter, subjects were observed performing multi task of lifting the flour bag / (steel/aluminium) boxes/ sac of approximately 5/10/15 and 20 Kg from ground and placing on shelves at approximately 120 - 170 cm followed lifting them and pouring the grains in the flour mill prior and then collecting the same after grinding in the same bag / (steel/aluminium) boxes/ sac and pushing it across the room for collection by the clients. Pictures and videos were acquired and analysis of the NIOSH tool was done thereafter. Shape of the boxes used were generally cylindrical at times rectangular, not having handles or hand hold cut outs, the coupling is defined as bad, asymmetric lifting is involved (i.e A=1), moderate lifting duration of 2 hours.

The procedure involved in the study is as follows

Pre-mapping done using the EPM questionnaire. The risk assessment done according to the classification of colour marking obtained on assessment. Levels of Risk Factors according to first level of pre-mapping was as follows: Levels of risk factors are calculated as per the responses of the workers and were denoted by the colour coding in the software.

G = GREEN - acceptable . no further actions are required
Y= YELLOW – neither acceptable nor critical – risk assessment will have to be carried out using the analytical methods
R= RED - neither acceptable nor critical – risk assessment will have to be carried out using the analytical methods
P= PURPLE – critical code. definitely a significant occupational risk and immediate corrective actions will be required. Such operations may represent a serious risk of injury & should come under close scrutiny, particularly when the entire weight of the load is supported by one person.

Second-level pre-mapping assessment presents scores between 0% and 10%, the colour green will appear; for scores up to 50% the colour yellow will appear; for scores between 50% and 99% the colour will be red; for scores of 100% the colour will be purple, which is always used to indicate the highest possible score, and therefore indicates a critical condition. Following the risk analysis the lifting index was calculated as explained in the procedure below.

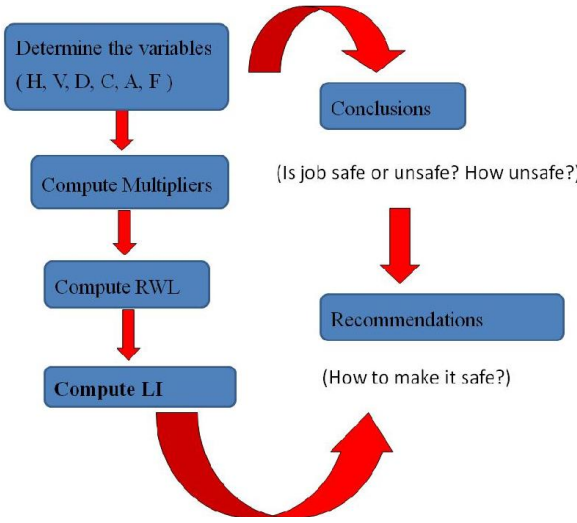

Figure 2. Procedure of NIOSH

Figure 2 shows the steps involved in the procedure of applying NIOSH tool of assessing lifting index

The procedure for using NIOSH is in following steps:

- The posture or postures for assessment are selected.
- Variables are determined (H, V, D, C, A, F)
- Multipliers are computed using the NIOSH software
- RWL, LI are computed
- The postures are scored using the scoring sheet, body-part diagrams, and tables.
- These scores are converted to one of the four action level.

Lifting Index (LI)

LI is a term that provides a relative estimate of the level of physical stress associated with particular manual lifting task. The estimate of the level of physical stress is defined by the relationship of the weight of the load lifted and the recommended weight limit.

LI is defined by: - LI= Load weight (L)/RWL
If, LI <1 = Low Risk
LI >1<3 = Mild / Moderate Risk
LI >3 = High Risk

Recommended weight limit (RWL)

The RWL is the principal product of the revised NIOSH lifting equation. The RWL is defined for a specific set of task conditions as the weight of the load that nearly all healthy workers could perform over a substantial period of time (e.g. up to 8 hrs) without an increased risk of developing lifting related low back pain. By healthy workers, they mean workers who are free of adverse health conditions that would increase their risk of musculoskeletal injury. The revised equation takes into account six variables that are associated with every lift. The variables are translated into equation multipliers.

The RWL is defined by

RWL=LC*HM*VM*DM*AM*FM*CM

RESULTS AND DISCUSSION

Demographic characteristics of the subjects enrolled in the study is reported in Table 1.

Table 1. Demographic characteristics of the subjects in the study

	Age	Years of service
Average	40.8	17.51
Max	64	43
Min	20	1
Std Dev	11.01	9.78

Risk pre-mapping tool assessed factors like biomechanical overload, repetitive movement, lifting/ carrying heavy loads, pushing-pulling, awkward postures adopted. Organizational factors like shift work, work duration and work rate; Physical factors like lighting, noise pollution, microclimatic issues, vibrations equipments / tools and machinery handled and chemical and biological factors like pollutants etc were also assessed based on the responses of the subjects on the EPM risk pre-mapping tool. Frequency tables were synthesized using SPSS software for distribution of number of subjects falling in each category risk factors; viz: green, amber, red and purple zones as described earlier. Table 2 enlists the number of mill workers falling in the each zone of risk factor as obtained from the EPM pre-mapping tool for biomechanical overload- on upper limb in repetitive tasks, in Manual Lifting, in Manual Transport, in Manual Pulling and Pushing and on Spine and lower limb awkward posture. The pre-mapping software generates the appropriate colour below the light: green (no postural problems for the back or lower limbs), yellow (slight discomfort), red (discomfort present calling for further investigations), purple (critical discomfort present requiring urgent investigation). It was a deliberate decision to avoid assigning a score to these initial indicators, and rather to use colours to depict either the absence of the problem or the presence of the problem and the need to deal with its more or less urgently (colour-coded priorities).

Biomechanical overload assessment showed that most of the workers were at high risk of overloading their upper limb in repetitive activities whereas overload due to manual lifting showed that 10 workers were at a very high risk and critical condition and required urgent intervention and correction. Manual transport again was obtained as a high risk factor for most of the workers. 70 workers showed that they were at a high risk of biomechanical overloading due to manual pushing and pulling activities and 23 were and no risk from the same. 47 flour mill workers posed a very high level of risk denoting a serious risk of injury and should come under close scrutiny, particularly when the entire weight of the load is supported by one person. Also 50 workers showed high level of risk denoting prompt action needed for the same. Therefore, postures adopted by the workers have a very harmful effect on musculoskeletal system and corrective action should be taken as soon as possible.

Questions for identification of inside lighting problems as for all the other sections of the pre-mapping form, these questions are also closed-ended and refer to the visual effort required to perform the work in relation to the lighting both at the work station and in the work place with respect to general and localized lighting and kind of surfaces. The results showed that on an average around 30 workers were at medium risk and 10 workers were at high risk whereas maximum number of workers reported that they were comfortable and thus posed a low level risk in green colour coding. Table 3 shows the findings of this category. Questions for identifying problems relating to noiseshowed that it was a major distracting factor for the workers and that it posed as a high risk factor at their work place when the miller would be working. However, the task does not require verbal communications with co-workers while the machine is on; hence it was assessed as being a low level risk factor as far as noise is concerned. Questions for identifying problems relating to the microclimate showed that all the workers complained of heat and humidity all year long as they working in a flour mill factory warrants the workers to work in a environment with no ventilation and air facilities. As a ceiling fan could hamper and dust the area heavily, they often had to avoid the use of same during summers and otherwise too. Questions for identifying problems relating to the use of tools/equipment showed that the workers used machine grinders which were heavy, noisy, cumbersome to use and hard to be handled single handedly, they overheat easily and require regular servicing of the stones used in the grinding machine.

Table 2. Distribution of flour mill workers in each category of risk factor as assessed for biomechanical overload while at work

	Number of Workers			
	Green	Yellow	Red	Purple
Categories of Risk factor	Low level of risk	Medium level of risk	High level of risk	Very High level of risk
Biomechanical Overload of UL In Repetitive Task (B1)	0	2	96	2
Biomechanical Overload-Load Manual Lifting (B2)	0	0	90	10
Biomechanical Overload-Load Manual Transport (B3)	6	0	94	0
Biomechanical Overload-Load Manual Pulling & Pushing (B4)	23	0	70	7
Biomechanical Overload-Spine & Lower limb Awkward Posture (B5)	0	3	50	47

Table 3. Distribution of flour mill workers in each category of risk factor as assessed for identification of inside lighting problems

	Number of Workers			
	Green	Yellow	Yellow	Purple
Categories of Risk factor	Low level of risk	Medium level of risk	High level of risk	Very High level of risk
General lighting: judgment of visual effort required at work	60	30	10	0
Localized lighting. judgment of visual effort required at work	70	30	0	0
Kind of surfaces: judgment of visual effort required at work	80	20	0	0

The machine basically comprises two huge circular stones that are required for grinding the grains run by motor. These stones require to be beaten up in pellets with a large nail and a hammer so as to increase the granulations and friction to be caused by these stones that grind the grains. They also have to handle and lift up boxes, bags or sacks of grains to be unloaded into the grinder for grinding, and loaded with flour post to the grinding process. Similarly, questions for identifying problems relating to vibration showed that most of the workers needed to use the grinders for at least 1/3 of the total work time in a day. And they also made used of the hammers to unpolish / increase the surface area of the grinding stones for the earlier part of the day daily; there by, exposing the flour mill workers to high and very levels of risk of equipment use and vibrations from these machines respectively.

On same lines, questions for identifying problems relating to machinery showed that the grinders did not need much force to be operated, albeit needed force for handling before they are put to use, the machines as mentioned earlier were noisy, and there is usually not much space to be moving in and around the grinders for operation purposes.

Therefore, this factor too posed a high risk to the flour mill workers. As regards questions for identification of problems associated with pollutants, and Biological or other special agents the workers responded that they had to face a high presence of flour dust all the time once the grinder started as the flour would spread everywhere and these workers are covered with the flour most of the times at work. This definitely shows a high risk of health hazard to these workers; however, there are no serious chemicals involved in the process of their work, thus, pre-mapping assessment showed that there was a mild risk and further evaluation is not necessary although there needs to be an observation regarding this factor at their work place.

Questions for identifying organizational problems showed that the workers had to be working for more than 8 hours a shift and they had problems with rate of work imposed by the machines as they required frequent servicing after a few rounds of grinding. Second level pre-mapping assessment scores showed an average of following percentages in each category in summary of results (0% and 10%, the colour green will appear; for scores up to 50% the colour yellow will appear; for scores between 50% and 99% the colour will be red; for scores of 100% the colour will be purple, which is always used to indicate the highest possible score, and therefore indicates a critical condition.)

Table 4. Second-level pre-assement scores in percentages as shown from the summary of results in the software

Biomechanical factors	
B1. Repetitive movement	100%
B2. Lifting	100%
B3. Carrying	60%
B4. Pulling- pushing	50%
B5. Spine and lower limb awkward postures	100%
C. Lighting	60%
E. Noise	75%
F. Microclimate issue	65%
G. Equipment and tools	58%
H. Vibration	100%
I. Machinery	58%
L. Pollutants	100%
M. Organizational	55%

It was ascertained that the manual lifting work is definitely at risk as there were more than one reply in this group for the critical code section as positive. Upgrades or remedial action was thus needed to be undertaken urgently with regard to the conditions defined as critical, to be followed by a risk assessment using Revised NIOSH lifting equation. NIOSH equations yielded an average recommended weight limit (RWL) as 6.56 Kg whereas the average weight lifted was more than RWL and valued at 9.02 Kg. Lifting Index was calculated

by the NIOSH software. It was calculated as the ratio of lifted weight and recommended weight. The results were classified as explained earlier (LI <1 = Low Risk, LI >1<3 = Mild / Moderate Risk, LI >3 = High Risk) and the average number of workers falling under each criteria was analysed and are depicted in Table 5 and shown in Figure 3.

Table 5. Frequency of Workers in each category of risk factor as per Lifting index

Low Risk	Moderate Risk	V. High Risk	Total
19	76	5	100

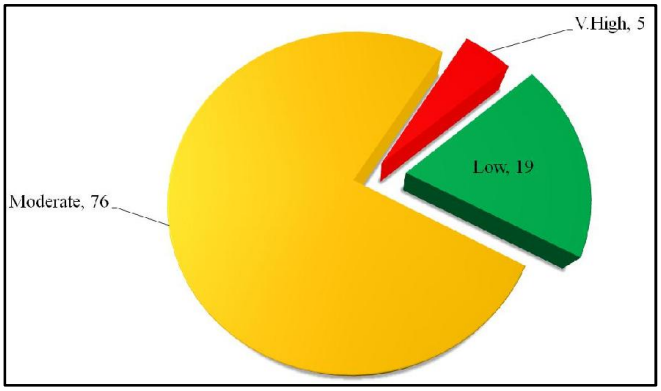

Figure 3. Number of people depicting the type of risk factors obtained in the pre-mapping tool off risk factor assessment

Conclusion

Flour Mill workers work in extreme awkward postures at their workplace which makes them vulnerable to health hazards. They have high risk of being inflicted with Low back injuries (Spine), either cumulative or acute in nature. NIOSH makes it evident that the Lifting index and the load lifted in manual transport are the highest risk factors in their job demands which could lead to the above mentioned problems. Also, the workplace environment comprising poor lighting, vibrations, microclimatic conditions and pollutants (flour dust) does affect the working conditions negatively.

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