A Biomechanical Risk Assessment of Lifting Tasks in the Logistics Industry in the Philippines

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Abstract

This paper aims to assess the biomechanical risks involved in the lifting tasks of workers in the logistics industry in the Philippines. Previous studies have proved that workers in the logistics industry are exposed to occupational risks of developing musculoskeletal disorders (MSD) and injuries due to the nature of their job. Workers in the logistics industry commonly employ heavy manual tasks that involve lifting, pulling and pushing; that can become hazardous and could cause significant and even irreversible injuries and disorders. Based on studies, several factors can contribute to the risks of workers such as repetitive movement, sustained force, awkward posture and weight of object being lifted to name a few. According to OSHA, the best and most effective way to eliminate or minimize the risk of MSD and injuries is to consider manual task hazards and risk during the design and planning stage of a workplace or a job. During this stage, hazards and risks can be eliminated before they are introduced into a workplace. Given these conditions, the authors intend to identify significant factors that contribute to the occupational risks of workers while performing lifting task in order to develop a mitigation plan that will help eliminate MSD and injuries of the workers. Key findings from the study revealed that workers experience MSD and injury in their lower back, upper back, hips/thigh, shoulder and wrist. Similarly, result of rapid entire body assessment (REBA) and NIOSH lifting equation proved that workers are exposed to high risk of MSD due to their poor working posture and repetitive work activities. Risk factors identified in the study were further treated and analyzed using correlation and regression analysis. The result revealed that factors such age, body-mass index, frequency of lift, weight lifted, lifting posture and duration of lifts significantly affect the risk and exposure of workers to work injury and musculoskeletal disorders with coefficient of correlation (R) values of 0.812 and 0.832 respectively. The identified factors serve as the basis for the researchers to develop risk mitigation plan to minimize the MSD and injuries experienced by workers.

Keywords
Biomechanical risk, lifting task, logistics industry

I. Introduction

Logistics can be defined as the management of the flow of goods, information and other resources, energy and people between the point of origin and the point of consumption in order to meet the requirements of consumers. Logistics involve the process of manual material handling, manual packing and other various activities that needed manpower or strength that may cause physical stress for a long period of time and repetition of task that may involve accidents such as musculoskeletal disorder, fatigue, injuries, and other respiratory diseases (www.osha.com.)

Previous studies have revealed that musculoskeletal disorders are most prevalent occupational health problems affecting manual workers (Stattin & Jarvholm, 2005). In the Philippines, there are 125,974 reported cases of MSDs in establishments employing 20 or more workers (PSA, 2015). The work related MSD escalated during the two-year period (2013-2015), accounting to 58.5% of all injuries and illness cases for all industries. It was also reported that 1 out of every 3 occupational diseases recorded were back pains (32.8%). Back pain is the highest in industries involving manual labor such as in logistics industry.

Workers in the logistics industry are frequently exposed to occupational risk factors such as repetitive motions (lifting/lowering task), awkward posture and lifting weights, which contribute to major causes of MSDs (Da Costa & Viera, 2010; Griffith et al., 2012). According to Karwowski (2001), the most important risk factors associated to manual lifting task are the amount of weight being lifted and awkward posture of workers because these factors require maintaining muscle force over an extended period of time. Repetitive and prolonged lifting tasks could cause muscle fatigue and discomfort for a worker and can significantly increase their risk of developing MSDs (Gumasing & Pacheco, 2018; Gumasing & Sasot, 2019).

In all kinds of work, workload and inappropriate posture may expose employees to injuries and musculoskeletal disorders (Szabo, 2004). Risk factors that may contribute to work musculoskeletal disorders and discomfort may include awkward posture, material handling, repetition, force, mechanical compression, vibration, temperature extremes, glare, inadequate lighting, and duration of exposure. Therefore, risk factors associated with musculoskeletal disorders should be identified in order to develop mitigation plan to prevent MSDs and injuries of workers in logistics industry.

2. Methodology

The researchers conducted the study among the three (3) largest logistics companies in the Philippines namely: LBC Express, JRS Express and DHL Express. A total of 55 respondents were involved in the study including 42 logistics/courier workers, 4 drivers and 9 supervisors/managers. The researchers have conducted review of related literature, direct observation, surveys, interview and actual data gathering in order to identify occupational risk factors in the lifting tasks of workers. The factors considered in the study were classified into two, namely (1) personal related factors: age, BMI, years of service and (2) task-related factors: frequency of lifts, weight lifted, lifting posture assessment and duration of lift. The researchers used Nordic Musculoskeletal Questionnaire (NMQ) in order to determine the discomfort location and common types of musculoskeletal disorders experienced by logistics worker when performing their tasks. The NMQ has been widely used to assess the nature and severity of self-related musculoskeletal symptoms. The questionnaire includes items asking about the experience of MSD in 9 body areas (neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thigh, knees and ankles/feet) over the past week and over the past year. Thus, weekly and annual prevalence of MSD can be derived (Kuorinka, et al., 1987) Postural analysis was also done in order to gather data for task related factors. The researchers used Rapid Entire Body Assessment (REBA) to evaluate whole body postural MSD and measure risks associated with the task of the workers. NIOSH lifting equation was also used to assess the manual material handling risks of workers associated with lifting and lowering tasks in their job.

2.1 Statistical Analysis

Descriptive measures were used to provide an analysis of occupational risk factors obtained from data gathering. This helped the researches to come up with analysis and draw appropriate conclusions without bias. Collected data from survey, interview and observations were arranged in a manner of which the data can be easily interpreted through the use of frequency count and percentage distribution. In addition, the factors considered in the study were statistically treated and analyzed using correlation analysis and regression method. Correlation analysis was used to determine the strength of relationships between the occupational risk factors considered in the study to the musculoskeletal disorders and injuries experienced by the workers. Moreover, the significant factors identified were further analyzed using multiple regression analysis to examine the relationship of the predictors and determine how they affect the musculoskeletal disorders and injuries of workers in their lifting tasks.

3. Result and Discussion

The table below showed the summary of injuries experienced by workers in the logistics industry for the past 3 years (2015-2017) gathered from interview, survey and historical records of the companies. In addition, result of NMQ is

also presented to allow comparison of the musculoskeletal disorders and complaints experienced by workers in their lifting tasks for the past 12 months and last 7 days which has prevented their normal activity.

Table 1. Summary of Injury (2015-2017)

TYPES OF INJURIES (2015-2017):		
Injury:	Frequency:	Average Days Lost:
Arm Fracture	1	6
Scratches/Abrasion	3	0
Cuts/Wounds	2	0
Neck Injury	3	2
Low Back Injury	15	1
Upper Back Injury	12	2
Hips/Thigh Injury	10	1
Shoulder Injury	10	2
Wrist Injury	9	1
Total	65	15

Table 2. Summary of Musculoskeletal Disorder using NMQ

Prevalence Rate for MSD		
Body Part	Occurrence in last 12 months (%)	Occurrence in last 7 days (%)
lower back	43	23
upper back	27	18
hips/thigh	21	12
shoulder	38	14
wrist/hands	24	8
neck	18	6
elbow	12	4
knees	8	3
ankles/feet	4	2

Overall, the MSD symptoms were widely reported by the participants of the study. 85% of the respondents reported that they had experienced MSD in the past 12 months while 24% of the respondents reported that they had experienced MSD over the past 7 days. In can be observed that lower back pain is the most prevalent MSD reported followed by shoulder, upper back, wrist/hands, hips/thigh, neck, elbow, knees and ankles/feet for both the past 12-month and 7day period.

3.1 Result of Postural Analysis

In order to validate the cause of discomfort and MSD of workers, the researchers conducted rapid entire body assessment (REBA) on the following tasks commonly employed by the workers in the logistics industry. The result is shown in the table below.

Table 3. Summary of REBA Scores

Tasks	Score A	Score B	Score C	Activity Score	REBA Score	Remarks
Pushing/pulling of cargo	7	3	7	3	10	high risk
Carrying of cargo	5	4	5	3	8	high risk
Stacking of cargo	4	6	6	3	9	high risk

The result of REBA scores indicated that the current posture of workers in lifting and carrying of cargo pose high risk of MSD for workers primarily to upper limb and lower back, that is why the task postures must be investigated and changed immediately.

The researchers also assessed the lifting posture of workers using NIOSH Lifting Equation. The job resulted in poor lifting conditions, which caused for concern as the location of the hands of the workers when lifting is outside the preferred lifting zone of 75 cm to 110 cm vertical height and horizontal reach of 40 cm based from 5th percentile female reach distance with elbow at side of body (Pheasant & Haslegrave, 2006). This proved why majority of the workers experienced pain and MSDs on their parts of the body as reflected in the NMQ scores of the respondents. The result of NIOSH lifting equation is shown in the table below.

Table 4. Summary of NIOSH Scores

Tasks		HM	VM	AM	DM	CM	FM	RWL	LI	Remarks
Unloading of cargo from truck	Origin	0.78	0.72	0.71	0.72	0.95	0.88	12	**0.90**	**No risk**
	Destination	0.77	0.78	0.81	0.72	0.95	0.88	15	**0.74**	**No risk**
Loading of cargo into truck	Origin	0.75	0.72	0.88	0.74	0.95	0.88	15	**0.73**	**No risk**
	Destination	0.81	0.81	0.71	0.74	0.95	0.88	15	**0.75**	**No risk**
Stacking of cargo	Origin	0.62	0.65	0.71	0.64	0.95	0.88	8	**1.41**	**Risky**
	Destination	0.61	0.63	1	0.64	0.95	0.88	10	**1.05**	**Risky**
Lifting of cargo for scaling/weighing	Origin	0.63	0.61	0.71	0.82	0.95	0.79	9	**1.28**	**Risky**
	Destination	0.62	0.65	0.71	0.82	0.95	0.79	9	**1.22**	**Risky**

Based on the analysis made on the present lifting task posture of workers, the NIOSH lifting equation illustrated that the tasks such as stacking of cargo and lifting of cargo for scaling/weighing posed an increased risk for lifting related low back pain and injury for some fraction of the workforce.

3.2 Result of Statistical Analysis

Correlation analysis was used to show the relationships of risk factors gathered from initial assessment of data to the occupational MSDs and injuries of workers in the logistics industry. The result is shown in the table below.

Table 5. Result of Correlation Analysis

PERSONAL FACTORS		TASK RELATED FACTORS	
age		**frequency of lifts**	
Pearson correlation	0.742	Pearson correlation	0.876
p-value	0.000	p-value	0.000
BMI		**weight lifted**	
Pearson correlation	0.668	Pearson correlation	0.812
p-value	0.000	p-value	0.000
years of service		**work posture**	
Pearson correlation	0.324	Pearson correlation	0.768
p-value	0.789	p-value	0.000
		lifting posture	
		Pearson correlation	0.812
		p-value	0.000
		duration of lift	
		Pearson correlation	0.714
		p-value	0.000

Based on the results, factors that have strong positive correlation to MSD experienced by workers in their tasks are frequency of lifts, weight lifted and lifting posture; while factors such as age, BMI, work posture and duration of lift have only moderate correlation to MSD. This explains that as the value of these factors increases the severity of MSD of workers also increases.

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These factors were further treated and analyzed using regression analysis to verify true predictors of MSD of workers as shown below.

$$Injury\ Score = 2.32 + 0.445\ frequency\ of\ lift + 0.542\ weight\ lifted + 0.655\ duration\ of\ lift \quad (1)$$

$$MSD\ Score = 11.23 + 0.032\ age + 0.215\ BMI + 0.687\ frequency\ of\ lift + 0.782\ weight\ lifted + 0321\ work\ posture \\ + 0.012\ lifting\ posture + 0.541\ duration\ of\ lift \quad (2)$$

The model summary for the regression model incurred an adjusted R of 85.4% and 86.32% with coefficient of correlation (R) values of 0.812 and 0.832 respectively, which explained that independent variables in the equation are strong predictors for the MSD and injuries of workers in the logistics industry.

3.3. Manual Material Handling Techniques and Lifting Techniques

Since the majority of work posture and muscle activities of the workers in their present material handling and lifting tasks cause musculoskeletal pain and disorders, the author made recommendations were made on the proper lifting techniques and manual material handling procedure.

> **Lift the load properly.** The use of a diagonal foot position and getting close to the load as possible is the ideal lifting procedure. Lifting from the floor minimizes the strain in the lumbar spine. Also as much as possible, weight load should be kept as close to the body as possible when standing up. It is easier to lift or move loads that are waist height than on the floor. See figure 1.

> **Carry the load properly.** The workers should keep all loads as close to one's center of gravity, and when lifting anything with a handle, one hand should be placed on one knee to get additional leverage and a diagonal foot position should be used. Furthermore, carrying two objects of the same weight will balance the load as long as the weight of the load is reasonable. See figure 2.

> **Use "three-point" contact.** When climbing **with** a load, "three-point" contact is important for safety. This means two hands and a foot or both feet and a hand must be in contact with the ladder or stairs at all times. If the load is bulky, another person or a mechanical device must assist. See figure 3.

> **Push or pull the load.** Manual material handling may require pushing or pulling**.** Pushing is generally easier on the back than pulling. It is important to use both the arms and legs. A handle would ideally be waist high for ease of pushing. If necessary to pull, avoid twisting the lower back. Meanwhile for very large loads, turning around and using the back to push against an object allows the legs to provide maximum force while protecting the low back from strain or twisting. See figure 4.

> **Pivot.** Pivoting means moving the shoulders, hips and feet with the load in front at all times. The lower back is not designed to torque or for repetitive twisting. When having manual material handling, always avoid twisting the back. See figure 5.

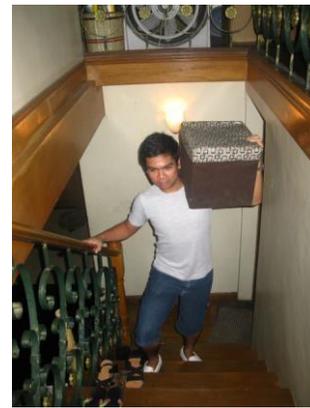Figure 1. Lifting posture   Figure 2. Carrying posture   Figure 3. Three-point contact

Figure 4. Pushing/pulling load   Figure 5. Pivoting

4. Conclusion

The findings of the study have proven that workers in logistics industry are exposed to risks of musculoskeletal disorders and injuries due to heavy exposure to manual material handling and lifting tasks. The risk was evident on the scores generated by REBA and NIOSH computed from their body postures while performing tasks. Based on the result of NMQ, majority of the respondents experienced pain in their lower back, upper back, hips/thigh, shoulder and wrist. Several risk factors were considered in the study based on review of related literature, direct observation and interview from the people involved in the tasks. It was determined using statistical analysis that risk factors contributed to the MSDs and injuries of workers are age, body-mass index, frequency of lift, weight lifted, lifting posture and duration of lifts significantly affect the risk and exposure of workers to MSD and work injury. The identified factors serve as the basis for the researchers to develop proper manual material handling technique and lifting technique to minimize the MSD and injuries experienced by workers.

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