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Musculoskeletal Symptoms and Posture Analysis of Reach Truck Operators

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Abstract. Warehouse operations typically involve tasks that require great physical strength and power in order to move heavy loads from one point to another. However, this is not always the case as there are industrial vehicles that are of great help in order to perform certain tasks faster and with little effort. One of these is a reach truck, a type of forklift, which is the focus of this study. By conducting a survey using CMDQ, ratings were evaluated in order to determine the most prevalent musculoskeletal symptoms among reach truck operators. Body discomfort is most prevalent in the upper back, followed by the shoulders, neck, and lower back. Meanwhile, the posture analysis using REBA and RULA suggested that there is a medium to a high level of risk to the human body, further investigation is needed, and ergonomic intervention must be undertaken soon. This study reveals the need to re-evaluate the industrial vehicle's design or reconsider using alternatives.

Keywords: reach truck, warehouse, musculoskeletal symptoms, rapid upper limb assessment, rapid entire body assessment

1. Introduction

Warehouse management plays a strategic role in the supply chain. [1]. A warehouse is a facility that is used by businesses for storing goods [2]. Warehouse operations include receiving, putaway, picking, packing, dispatching, returns, and other value-adding activities [3]. Material handling takes place when performing these activities.

Material handling refers to the movement, protection, storage and control of materials and products in the context of manufacturing, warehousing, distribution, consumption and disposal [4]. In material handling, a range of industrial vehicles, equipment, machines and systems to support logistics operations are being used. Among these are forklifts that are very common in every warehouse facility. Forklifts are generally used for moving heavy loads of goods from one point to another faster and with little effort. They are also capable of bringing loads up and down the high racks.

However, warehouse truck operators, including forklift operators, are extensively exposed to work-related illnesses and accidents [5]. Because of that, forklifts have been a subject for many ergonomic studies. Existing studies tackle health-related problems [4], [6]-[8], ergonomic solutions [5], [9], design [10]-[13], and many more.

While there had been several ergonomic-related studies on the use of forklifts, there hasn't been a study that focused mainly on one type of forklift, which is the reach truck. A reach truck [14] is a type of forklift mainly used for narrow aisle applications. Figure 1 shows an example of a reach truck that has a side-facing operator seat.

This study aims to focus on a specific type of forklift which is the reach truck. It identifies the most prevailing musculoskeletal symptoms among reach truck operators. Additionally, with posture analysis, it determines the level of risk to which operators are exposed and the priority level of actions needed for intervention.

Fig.1. Reach truck.

2. Methodology

2.1. Participants

The participants of the study were warehouse workers, who are authorized and have the license to operate a reach truck. These workers are primarily responsible for the putaway of materials. Putaway refers to the warehouse process that happen between receiving a supply of goods from a vendor and having it all stored away in racks and shelves in the warehouse. [14].

The study was conducted in a warehouse that is a third-party logistics (3PL) facility of a pharmaceutical company.

2.2. Data Collection

A survey was conducted using the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) [15] for sedentary workers among the reach trucks operators. There were 10 warehouse workers, all male, who participated in the survey in which the questionnaires were distributed personally. CMDQ was used to determine the musculoskeletal symptoms or body discomfort experienced by workers in operating a reach truck.

Rapid Entire Body Assessment (REBA) [16] and Rapid Upper Limb Assessment (RULA) [17] were used as instruments for the posture analysis. Actual observation was conducted while workers performed the putaway activity. The tasks observed included forward and reverse drive of the reach truck and storing articles up the warehouse rack. Video and photos were taken from the actual execution of the tasks to better evaluate body positions.

2.3. Statistical Analysis

Descriptive statistical analysis was used to interpret the data gathered from the survey using CMDQ. The ratings given by each participant were assigned weights in order to easily identify the most serious body discomforts. Scoring guidelines for the CMQD is shown is Table. 1. Discomfort score is computed by multiplying the frequency score by the severity score by the interference score. In the computational analyses missing values can be coded as 0. If the missing value is for the frequency score then use this as a zero in multiplying, i.e. all combinations of Frequency, Discomfort and Interference become 0. Discomfort scores for all workers were added to determine the total discomfort score for a body part.

Table 1: CMDQ Scoring Guidelines

Frequency	
0	Never
1.5	1-2 times last week
3	3-4 times last week
5	Once everyday
10	Several times every day
Severity	
1	Slightly uncomfortable
2	Moderately uncomfortable
3	Very uncomfortable
Interference	

1	None
2	Slight
3	Substantial

REBA and RULA scores were interpreted using the guidelines shown in Table 2 and Table 3.

Table 2: REBA Score Guidelines

	Risk	Action
1	negligible	not necessary
2-3	low	may be necessary
4-7	medium	necessary
8-10	high	necessary soon
11-15	very high	necessary now

Table 3: Rula Score Guidelines

1-2	acceptable posture
3-4	further investigation, change may be needed
5-6	further investigation, change soon
7	investigate and implement change

3. Results and Discussion

3.1. Musculoskelatal Symptoms (Body Discomfort)

Table 4 represents the scores derived from the survey using CMDQ. The ratings given by the workers were computed using the scoring guidelines in Table 1. The scores shown in Table 4 are the accumulated scores of all workers per body part.

Table 4: CMDQ Scores

Body Part	Frequency	Severity	Interference
Neck	42.5	17	16
Shoulder (right)	45.5	16	15
Shoulder (left)	44	16	15
Upper Back	45.5	17	17
Upper Arm (right)	19.5	10	11
Upper Arm (left)	16	8	11
Lower Back	35.5	14	15
Forearm (right)	10.5	7	12
Forearm (left)	10.5	7	10
Wrist (right)	16	10	12
Wrist (left)	12.5	8	11
Hip/Buttocks	7.5	5	10
Thigh (right)	6	3	10
Thigh (left)	4.5	3	10
Knee (right)	20	10	12
Knee (left)	16	9	11
Lower Leg (right)	4.5	2	10
Lower Leg (left)	4.5	4	11

Based on the survey, the workers experienced greater body discomfort or musculoskeletal symptoms on their neck, shoulders, upper back, and lower back. These body parts are the highest scoring in terms of frequency, severity, and interference. The right shoulder and upper back had the highest in terms of frequency with a score of 45.5. As for the severity, discomfort was felt most on the neck and upper back with a severity score of 17. On the other hand, upper back discomfort was most likely to interfere work with the highest score of 17.

Table 5 shows the total discomfort score for each body part. Overall, discomfort is highest on the upper back of the workers with a score of 137 or 16.79% of the total discomfort experienced among the 18 body parts listed. It was then followed by the neck (15.56%), right shoulder (14.64%), left shoulder (14.46%), and lower back (10.78%).

Table 5: Total Discomfort Score

Body Part	Score	%

Neck	127	15.56
Shoulder (right)	119.5	14.64
Shoulder (left)	118	14.46
Upper Back	137	16.79
Upper Arm (right)	30	3.68
Upper Arm (left)	19.5	2.39
Lower Back	88	10.78
Forearm (right)	13.5	1.65
Forearm (left)	10.5	1.29
Wrist (right)	31	3.80
Wrist (left)	23	2.82
Hip/Buttocks	7.5	0.92
Thigh (right)	6	0.74
Thigh (left)	4.5	0.55
Knee (right)	41	5.02
Knee (left)	26.5	3.25
Lower Leg (right)	4.5	0.55
Lower Leg (left)	9	1.10

3.2. Posture Analysis

Both REBA and RULA were used in order to obtain a numerical index that represents the quantitative value of the risk at which the workers were exposed during the putaway activity and to derive the priority level of intervention and the actions needed. The tasks that were evaluated in operating a reach truck were forward and reverse drive and storing an article up the warehouse rack. Figures 2, 3 and 4 illustrate these tasks.

Fig. 2. Forward drive.

Fig. 3. Reverse drive.

Fig. 4. Storing an article up the rack.

Table 6 shows the REBA results for the forward and reverse drive of the reach truck as these tasks have the same scores. With a final REBA score of 5, the risk level is Medium and necessary action must be undertaken based in Table 2.

On the other hand, Table 7 shows the REBA results for the task of storing up an article to the top of a warehouse rack which is a 4-level rack. The final REBA score for this task is 8, which indicates High level of risk and necessary action must be undertaken soon as suggested in Table 2.

Table 6: REBA for Forward/Reverse Drive

Neck, Trunk and Leg Analysis	Score
Neck	1
Neck Adjustment	1
Trunk	1
Trunk Adjustment	1
Legs	1
Legs Adjustment	2
Force/Load	0
Arm and Wrist Analysis	
Upper Arm	2

Upper Arm Adjustment	-1
Lower Arm	1
Wrist	1
Coupling	1
Activity Score	1
Final Score	**5**

Table 7: REBA for Storing Up an Article

Neck, Trunk and Leg Analysis	Score
Neck	2
Neck Adjustment	1
Trunk	2
Trunk Adjustment	1
Legs	1
Legs Adjustment	2
Force/Load	0
Arm and Wrist Analysis	
Upper Arm	2
Upper Arm Adjustment	-1
Lower Arm	1
Wrist	1
Coupling	1
Activity Score	1
Final Score	**8**

Furthermore, RULA was also used to evaluate the risk to the body of operating a reach truck for the same tasks. In Table 8, the final RULA score for driving a reach truck forward and reverse is 3. However, there is a difference in the neck position for these tasks. Forward drive neck score is 1 while reverse drive score is 2. The reason for this is the need to tilt down the head or neck slightly during reverse. Nevertheless, the final RULA score for both would still be still 3. According to Table 3, this score suggests that further investigation is needed, and change may be needed.

Meanwhile, Table 9 shows the RULA results for storing up an article to the top-level of the rack. The final RULA score is 6, which is an indication for further investigation and for a change to be undertaken soon as suggested in Table 3.

Table 8: RULA Analysis for Forward/Reverse Drive

Arm and Wrist Analysis	**Score**
Upper Arm	2
Upper Arm Adjustment	-1
Lower Arm	1
Lower Arm Adjustment	0
Wrist	2
Arm Muscle Use	1
Force/Load	0
Neck, Trunk and Leg Analysis	
Neck	1, 2
Neck Adjustment	1
Trunk	1
Trunk Adjustment	1
Wrist Twist	1
Legs	1
Upper Body Muscle Use	1
Force/Load	0
Final Score	**3**

Table 9: RULA Analysis for Storing Up an Article

Arm and Wrist Analysis	**Score**
Upper Arm	2
Upper Arm Adjustment	-1
Lower Arm	1
Lower Arm Adjustment	0
Wrist	2
Arm Muscle Use	1
Force/Load	0
Neck, Trunk and Leg Analysis	
Neck	4
Neck Adjustment	1
Trunk	1
Trunk Adjustment	1
Wrist Twist	1
Legs	1
Upper Body Muscle Use	1
Force/Load	0
Final Score	**6**

For both the REBA and RULA results, it showed that most of the adjustment scores are a result of twisting of the neck and trunk while performing all the tasks which contributed to higher final scores. This is mainly due to the orientation of the of the reach truck operator's seat which is facing the left side.

4. Conclusion

By conducting a survey using CMDQ and with the use of REBA and RULA, the musculoskeletal symptoms and risk associated with performing the targeted tasks using a reach truck were identified and evaluated [18], [19]. Musculoskeletal symptoms among the operators were prevalent in the upper back, both shoulders, neck, and lower back. Meanwhile, the posture analysis using REBA and RULA suggested that there is a medium to high level of risk to the human body, further investigation is needed, and ergonomic intervention must be undertaken soon. In the posture analysis, it was observed that adjustment scores were mainly attributed to the twisting of the neck and trunk while performing the tasks due to the sideway orientation of the reach truck seat. This study reveals the need to re-evaluate the design of the equipment or reconsider the use of alternative equipment.

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