Wrist Postures Analysis during Atilt Rolling Gas Cylinder Movement

Yi-Lang Chen, Hsi-Ting Chiang, and Da-Yung Lin

Abstract—**In this study, we analyzed a case of rolling the gas cylinder movement for a large technology company in Taiwan. Four experienced employees participated in this study and their cylinder transporting postures were analyzed by a goniometer. Results showed that, the repetitive activity for both wrists was as high as 1 time/s. The radial deviation for both wrists and the dorsiflexion on right wrist nearly reached the maximum range of wrist's motion. The occupied time percentage of awkward wrist postures during cylinder atilt rolling movement was also extremely high. This implied the tasks may potentially cause injury to the wrists.**

Index Terms—**Rolling cylinder movement, RULA, wrist postures**

I. INTRODUCTION

ACCORDING to the Council of Labor Affairs in Taiwan, after miners' pneumoconiosis disease, musculoskeletal disorders accounted for the highest proportion of occupational injuries between 1990 and 2007. In 2007, WMSDs accounted for 67% of all occupational injuries. Although government departments have endeavored to prevent WMSDs, a number of manual operations that involve fewer labors and automation that is not economically valuable have received relatively little attention. Continuous work and repetitive exertion under heavy loadings are the factors of WMSDs on the wrists [3]. Through on-site observations of the operations at a large technology company in Taiwan, we noticed that during the gas cylinder atilt rolling movement and positioning process, the employees' performed frequent and repetitive actions, with their wrists in unnatural postures and under heavy loads. However, few studies have investigated these operations. Weserling and Kilbom [7] biomechanically analyzed the worker's load on the upper extremity during dragging the gas cylinders. Devereux et al. [2] evaluated an assistant device for reducing musculoskeletal discomfort for manual handling of gas cylinders. However, the previous two studies focused on gas cylinder handling assessed the smaller cylinders and different moving ways. In this study, we tried to analyze the wrist postures during gas cylinder atilt rolling movements to clarify the potential WMSDs.

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II. TASK DESCRIPTION

The primary task conducted by this department is the changing of gas cylinders, which involves the atilt rolling and moving of cylinders between the storage area and the supply area. The operational procedures (from storage area to supply area) (as shown in Fig. 1) involved: 1) Release the chain bolting the cylinder (5s); 2) Atilt roll the cylinder movement from the storage area to the supply area. Place the cylinder next to the cylinder cabinet (35s); 3) Position the cylinder correctly, and then open the cap (15s). 4) Attach the new gas cylinder to the gas cabinet (20s); 5) The exchanged empty cylinders were taken in return (35s).

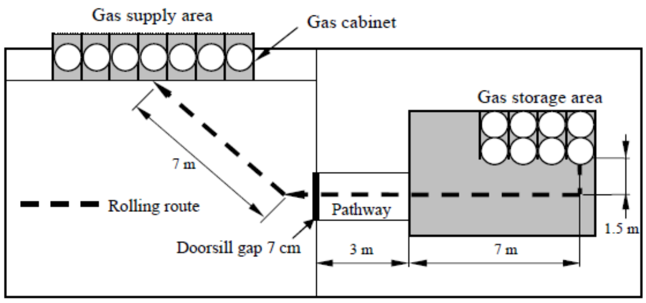

Fig 1. Site layout and route for transporting gas cylinders

Step 2 of the procedure required the gas cylinder to be moved for approximately 18 m and all employees were used to adopt the atilt rolling method. The gas cylinders must be exchanged 20 to 40 times per day; therefore, 40 to 80 trips rolling full cylinders to the cabinet and the empty cylinders return to the storage area are performed per day. Full cylinders and empty cylinders weighed 106 kg and 30 kg, respectively. The cylinders measured 140 cm in length.

III. METHODS

This study recruited 4 participants for the experiments. All participants with no prior history of musculoskeletal disorder volunteered for this study and provided informed consent, were paid, and made familiar with the testing procedure. Their basic and anthropometric data were recorded and measured, as listed in Table I.

For this study, we used a goniometer (Biometrics, U.K.) to record changes in the wrist postures, including palmar flexion, dorsiflexion, ulnar deviation, and radial deviation, for each participant during the gas atilt cylinder rolling movement. The sample frequency was 16 Hz and the entire process was recorded. After the goniometer was attached to the participant's wrists, the electric potential of certain wrist postures measured by the goniometer was documented and

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set as the calibration base.

TABLE I
BASIC DATA OF FOUR MALE PARTICIPANTS IN THIS STUDY

Items	Mean	Range
Age (years)	34.2	32 – 38
Stature (cm)	177.3	169 – 185
Body weight (kg)	78.1	64 – 92
Experience (yr)	5.5	1.5 – 9.8
Upper arm length (cm)	36.1	35 – 40
Forearm length (cm)	22.9	26 – 28
Hand length (cm)	19.1	17.6 – 20.0
Hand width (cm)	10.0	9.5 – 10.3

In the study, the 4 participants wore uniform as their duty time dressed. After each participant was familiar with the experiment procedure, three repeated formal rolling movements were performed. The participants were allowed at least a 5-min break between each trial, and were instructed to roll the gas cylinder at their used method with the normal pace.

IV. RESULTS AND DISCUSSION

Fig. 2 shows the postures involved in the gas cylinder atilt rolling movement and positioning operation. Regarding positioning the cylinder (Fig. 2 (B)), the cylinder must be tilted when being positioned. Usually, the cylinder been tilted backward all exceeded 30°, with some even reaching 45°. Based on mechanics, when gas cylinders were tilted to 30°, at least 27 kg of frontal pushing force was required for supporting a cylinder; similarly, the force was at least 38 kg when a cylinder is atilt supported at 45°.

(A) (B) (C)

Fig 2. The typical postures involved in the atilt rolling movement and positioning operation for RULA analysis (GRF: ground reactive force)

Fig. 3 shows the time percentage of how long a wrist posture was exposed during the rolling movement. As the figure shows, both wrists exhibited radial deviation for the majority of the time. Radial deviation (≥10°) of right wrist was exhibited for 45.2% of the time, and radial deviation (≥10°) of left wrist exhibited for 35.8% of the time. However, neither wrist showed severe ulnar deviation. Fig. 3 also shows that, during rolling movement, the palmar flexion of right wrist was exhibited greater than 30° occurring for 83% of the movement time. Palmer flexion of left wrist that exceeded 20° occurred for up to 37.5% of the movement time, with flexion greater than 10° occurring for 76% of the movement time. Injuries to the wrist may be difficult to avoid under such a high exposure to unnatural wrist postures and repetitive fluctuations.

Numerous studies have indicated that wrist injuries are highly related to the repetition of movements. Lin and Radwin [4] investigated the impacts of various repetitive wrist movements and applied forces ranging from 0.5 to 0.1 repetitions per second. They found that the frequency of operation and the participants' perceived discomfort were positively correlated. Marras and Schoenmmarklin [5] also found that operating frequency of the wrist was significantly correlated with wrist injuries. In this study, the average frequency of repetitive wrist movements performed by the four experienced participants was 1 time/s, regardless of the total movement time. The frequency was significantly higher than that reported by Lin and Radwin [4]. The radial deviation of both right and left wrists (approximately 17°) was near the maximum ROM (21.1°)[6].This was the same for the dorsiflexion of the right wrist (70°) in this study, with the maximum ROM around 75°[1]. Because the time percentage of unnatural wrist postures for the entire movement was high, as well as the estimated higher force (as shown in Fig. 2 (C)), the risk of musculoskeletal injury would increase significantly.

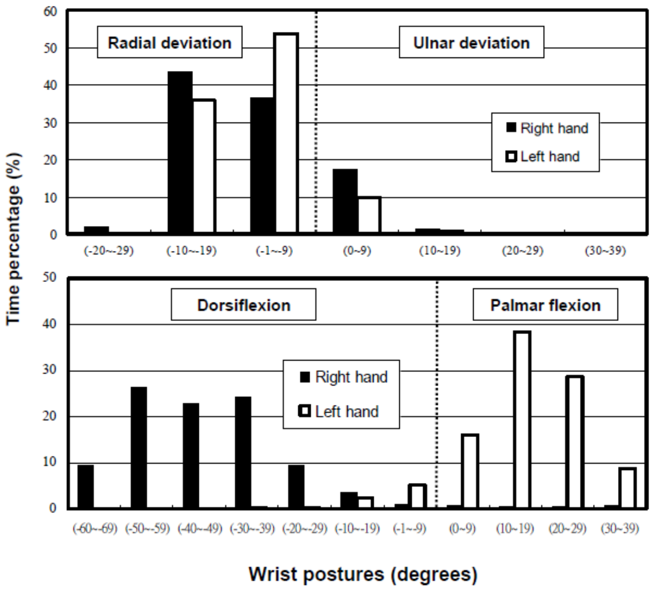

Fig 3. Time percentage of wrist postures during atilt rolling movement

V. CONCLUSION

Few studies have investigated the atilt rolling movement of gas cylinder operations. In Taiwan, these rolling movement operations are frequently conducted not only in the air supply department of manufacturing sites but also in many small liquefied petroleum gas (LPG) suppliers for families. The results of this case analysis can be used as a reference for related operation design and improvement.

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