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ANALYSIS OF MUSCULOSKELETAL RISK AMONG RAILWAY MAIL SERVICE WORKERS

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Abstract
Parcel service hub workers experience high physical workload due to the nature of their work activities. Demand of parcel services has tremendously been enhanced due to the social impact of COVID-19 pandemic. Consequently, prevalence of musculoskeletal disorders (MSDs) among these workers has increased. This study investigates MSDs among Railway Mail Service (RMS) workers in south Indian state of Kerala. The study also attempts to develop interventions to reduce MSDs among these workers. A preliminary study was conducted among 144 workers in RMS using Nordic questionnaire. Postural analysis was done in a simulated work environment using Rapid Upper Limb Assessment (RULA) and Ovako working posture assessment system (OWAS) to develop interventions. Based on the data collected, the workers were categorized as data entry worker, parcel sorting worker, and packaging worker. Results showed that data entry workers had higher prevalence of MSDs in wrist region. Sorting workers and packaging workers were experienced high degree of discomfort in shoulder and lower back region respectively. Musculoskeletal risk among data entry worker was reduced by modification of work method as an intervention in this study. An intervention of modifying work method and work layout reduced the MSD risk in sorting and packaging workers.

Keywords: Musculoskeletal disorders, Postural analysis, OWAS, RULA, Modelling.

1. INTRODUCTION

Parcel delivery services have become essential in today's world with their growth accelerated during and after the COVID-19 pandemic [1-2]. Musculoskeletal disorders (MSDs) are injuries and disorders that affect the movement or musculoskeletal system of the human body [3]. The increased work demands on parcel delivery service workers have led to enhanced pain symptoms and MSDs [4]. Postal services initially focused on mail delivery, now offer complex parcel delivery services with fluctuating physical demands of workers based on seasonal orders [5-6]. MSDs are causally linked to workplace activities, non-neutral postures, forceful/repetitive movements, and combinations of these exposures [7-9]. The prevalence of MSDs has been observed in workers who handle screen printing with forceful/repetitive movements and uncomfortable postures during work activities [10]. These injuries are often caused by poor posture and improper work activities. Poor job design, repeated motions, and unsuitable working conditions can cause muscle, ligament, and tendon discomfort [11], while prolonged standing can cause lower back discomfort, and improper workplace design and activities can force employees to stand in awkward positions [12].
By considering mail delivery services, the Railway Mail Service (RMS) deals with a high quantity of parcel deliveries [13]. The primary focus of RMS work is the sorting and processing of mail and parcels [14]. The activities carried out in RMS parcel services include data entry work, parcel sorting work, and packaging work. Among data entry workers, poor posture while working is a common issue that may contribute to the development of MSDs [15]. For parcel sorting employees, repetitive actions, uncomfortable postures, and heavy lifting are some of the known risk factors for MSDs [16]. Manual material handling can also increase the risk of MSDs, with poor posture, frequent lifting, and poor physical fitness being among the identified risk factors [17-18]. Research has explored the incidence and risk factors for musculoskeletal problems among the parcel service workers, highlighting the

necessity of ergonomic interventions to reduce these risks [19]. RMS plays an important role on providing quick deliveries in India. While there is limited literature on MSDs among the categories of RMS parcel hub workers, this study reports on the risks of MSDs among workers of RMS in Kerala state of India. Study also attempts to provide interventions to minimize musculoskeletal issues for all categories of workers in the parcel hub.

2. METHODOLOGY

In the present study, parcel service hub workers from the RMS were carried out. Data collected through self-reports Nordic Musculoskeletal Questionnaire (NMQ), direct measurements and observational methods.

2.1 Participants

Among twenty-three RMS parcel hubs in Kerala, six main RMS parcel hubs were selected for the study and 144 workers were participated. The selected parcel hubs include hubs at Thiruvananthapuram, Kollam, Ernakulam, Thrissur, Kozhikode and Kannur. The manual activities involved in RMS parcel hubs are data entry work, sorting and packaging. Data entry work includes data entry and barcode reading. Parcel sorting is divided into primary sorting and secondary sorting. Finally, the packaging work consists of bag opening and parcel packing. RMS parcel hub workers have day and night shift with a total working time of 8 hours per day.

Out of 144 participants, 24 of them were data entry workers, 76 of them were parcel sorting workers, and 44 of them were packaging workers. When considering the gender-based percentage distribution of RMS parcel hub workers, it seems that in data entry work 50% being male and 50% being female. In parcel sorting work 62% being male and 38% being female. Considering packaging work 82% being male and 18% being female. Demographic details of workers such as experience, age, height, weight, and Body Mass Index (BMI) are described in Table 1. Average age of data entry workers were 39 years and their BMI was about 24.3 kg/m^2. Similarly in parcel sorting workers average age of workers were 37 years and their BMI was about 24.7 kg/m^2. And in packaging workers average age was 36 years and their BMI was about 24.18 kg/m^2.

Table 1: Characteristic details of all categories of workers in RMS parcel service

Parameters	**Data entry Workers (Mean ± SD)**	**Parcel sorting Workers (Mean ± SD)**	**Packaging Workers (Mean ± SD)**
Experience (years)	12.00 ± 6.76	11.00 ± 6.49	11.00 ± 6.27
Age (years)	39.96 ± 6.99	37.25 ± 7.93	36.93 ± 7.41
Height (cm)	166.87 ± 9.66	168.10 ± 8.46	169.68 ± 7.05
Weight (kg)	67.87 ± 9.66	70.03 ± 10.13	69.77 ± 9.53
BMI (kg/m^2)	24.30 ± 2.55	24.70 ± 2.50	24.18 ± 2.55

SD: Standard deviation; BMI: Body mass index

2.2 Preliminary study and analysis

Information from the participants were gathered using standardized Nordic questionnaire [20]. This questionnaire generally utilized to determine the frequency of pain in these body locations during the previous year and the previous week, as well as any details regarding intensity or duration. As this study was conducted in Kerala, the Standardized Nordic questionnaire was translated into Malayalam language for data collection. The collected questionnaire data were analysed, and correlation analysis was performed using the Statistical Package for the Social Sciences (SPSS) software. The posture analysis and interpretation were carried out using the Siemens Tecnomatix Jack software, which allows for a detailed evaluation of different postures and their potential impact on the workers. Two commonly used methods for assessing working postures were employed: Rapid Upper Limb Assessment (RULA) score and Ovako Working Posture Assessment System (OWAS) score [21].

The RULA score provides a quick and simple evaluation of the posture and movement of the upper limbs, while the OWAS score provides a more detailed analysis of the entire body posture [22-24]. By comparing the results of these two methods, it is possible to identify which postures are causing more issues and should be addressed. The study verified the description of the RULA score results with the description of the OWAS results in posture analysis to find which posture is creating more issues. This allowed for a more comprehensive assessment of the impact of different postures on the workers and helped to identify areas where improvements could be made to reduce the risk of musculoskeletal disorders.

3. RESULTS AND DISCUSSION

This section includes results obtained from the analysis of data collected and developed interventions. Preliminary analysis was done based on the data collected using Nordic questionnaire. Correlation analysis was conducted using demographic variables such as age, experience, and Body Mass Index (BMI). Additionally, the study identified the risk of musculoskeletal disorders (MSDs) among different categories of workers in the RMS parcel hub by considering postural risk scores.

3.1 Preliminary Analysis

The present study analysed the prevalence of MSDs among different categories of workers in the Railway Mail Service parcel hub. Out of 24 workers in the data entry category, 87.5% had MSD issues, while 96% of the 76 workers in the parcel sorting category and 88.6% of the 44 packaging workers had the presence of MSD. This study found that parcel sorting work had the highest severity for MSD issues, followed by packaging and data entry work. Four main reasons for MSD were identified: forceful/repetitive movements, continued awkward posture, overexposure time, and lack of rest. The study collected opinions from workers regarding the reasons for MSD and found that most of the cases in all three categories were due to forceful movements, followed by continued awkward posture, overexposure time, and lack of rest, in that order of priority. Specifically, in the data entry category, 34% of cases were due to forceful movements, 29% due to overexposure time, 23% due to continued awkward posture, and 14% due to lack of rest. In parcel sorting and packaging, the percentages were 41%, 16%, 28%, and 15%, and 39%, 11%, 36%, and 14%, respectively. Overall, the findings suggest that the main issue for MSD in the Railway Mail Service parcel hub is due to forceful/repetitive movements, followed by continued awkward posture. Studies emphasised that impact of poor ergonomics leading to MSDs among data entry employees. Awkward postures, extended sitting, poor workstation design, and repetitive activities have all been highlighted as possible risk factors for MSD development in literature [25]. Also, the main reasons for MSD risk presence in mail sorting activities involved repetitive movements and improper postures [26].

From the analysis of Nordic questionnaire data, workers had prevalence of MSDs in different body parts. Figure 1 shows that in data entry work, many workers have high issues with their wrists/hands, neck, lower back and upper back. The findings in the literature also indicate that computer professionals who engage in data entry work are at an increased risk of MSDs in their upper body regions, particularly in their neck, upper back, and lower back regions [27-29]. However, the use of a barcode reader by data entry workers to scan parcels may increase the workload on their hands, which resulted in a conflicting result regarding the wrist/hand region.

Figure 2 shows that the parcel sorting workers have more issues with their shoulders, lower and upper back. Packaging workers mainly have issues with their lower back, shoulder, upper back, and wrist/hands (Figure 3). Literature reports that workers in manual material handling in warehouses, such as those involved in parcel sorting and packaging work, commonly experience lower back pain, neck pain, and shoulder pain [30-31]. In the case of grocery retail workers as being at high risk for MSDs, with a significant prevalence of discomfort in the upper back, lower back, and wrist regions [32]. These studies show that workers in industries such as parcel sorting and packaging frequently

experiences musculoskeletal discomfort in their lower back, upper back, and shoulder regions. Therefore, it is crucial to identify specific job tasks and activities that are associated with a higher risk of developing MSDs in these regions to prevent and reduce the incidence of these disorders.

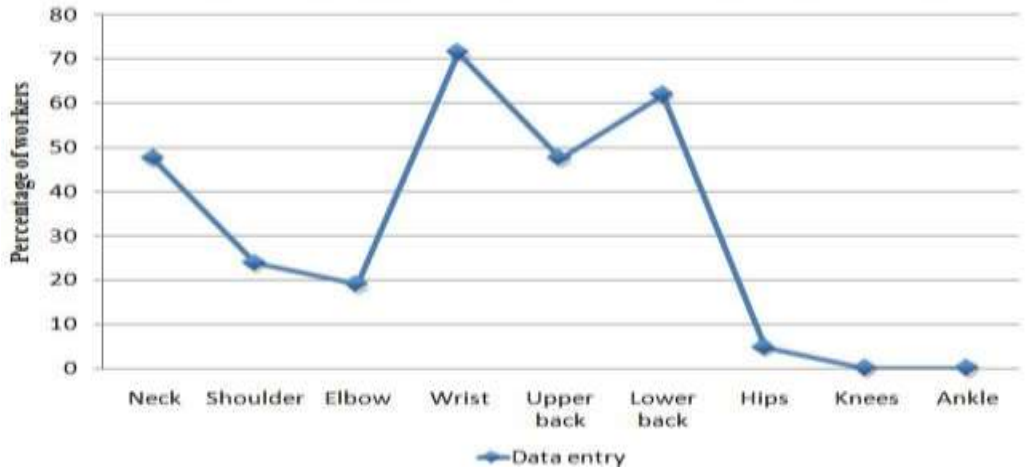

Figure 1: Percentage of data entry workers with MSD's in different body parts.

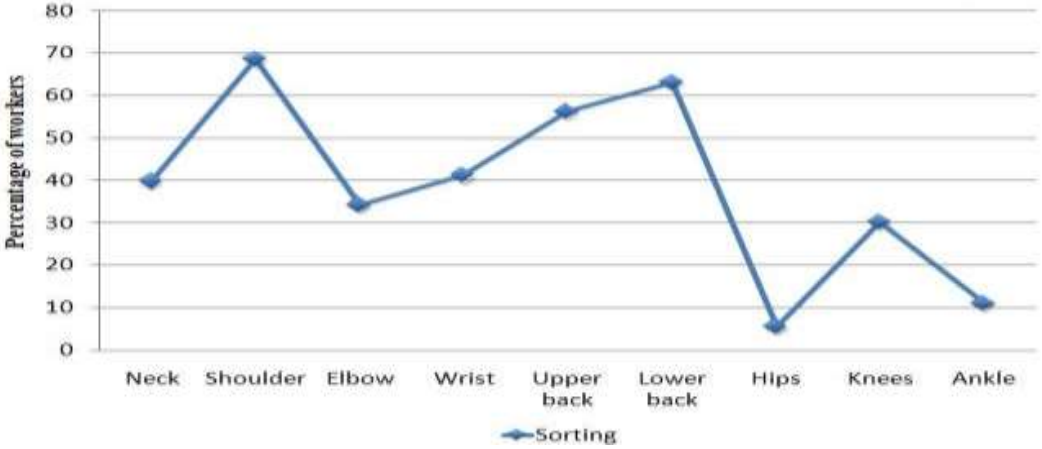

Figure 2: Percentage of parcel sorting workers with MSD's in different body parts.

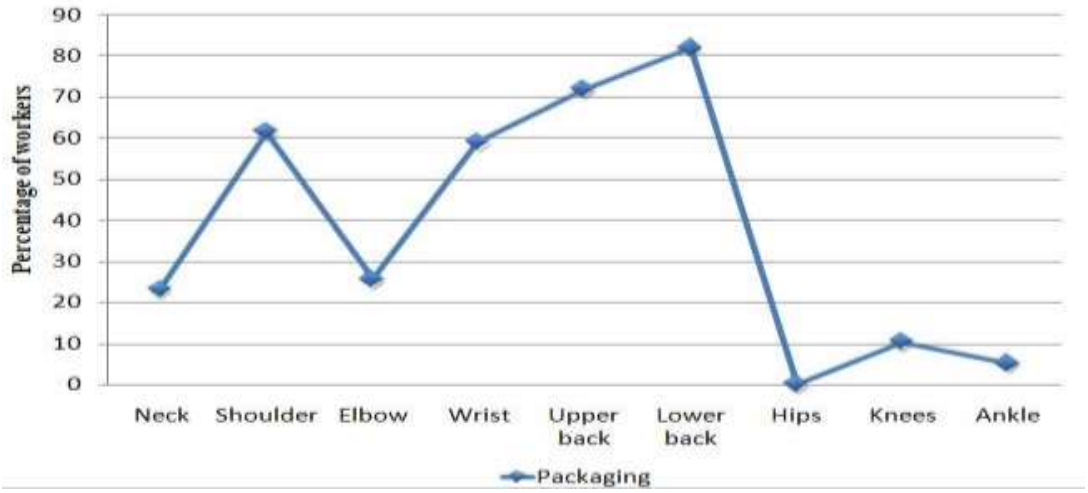

Figure 3: Percentage of packaging workers with MSD's in different body parts.

Correlation analysis

Spearman's rank correlation coefficient was used to correlate work experience, age and BMI with severity of discomfort in different body parts. Correlation analysis result of all categories of workers in RMS parcel hub is shown in Table 2. In data entry work, it was found that the prevalence of MSD in the shoulder and wrist regions significantly increases ($p < 0.01$) with age and work experience. Additionally, individuals experiencing discomfort in the lower back region significantly increases ($p < 0.05$) with work experience. In sorting work, the prevalence of MSD in the shoulder, elbow, wrist, upper back, lower back, and knee regions increases with the worker's age and work experience, with $p < 0.01$. In the shoulder region, the number of persons experiencing discomfort increased with their BMI, indicating that overweight workers have a higher probability of developing shoulder pain, with $p < 0.01$. Additionally, individuals experiencing discomfort in the hip region increased with an increase in BMI, with $p < 0.05$. In packaging work, the analysis showed an increase in the prevalence of MSD in the shoulder and knees regions with an increased working experience, with $p < 0.05$. Additionally, individuals who experienced discomfort in the elbow lower back, and knees regions showed an increase in age, with $p < 0.05$.

Table 2: Correlation analysis result of RMS parcel hub workers

Type of work	Factors affecting MSDs	Severity of discomfort in body parts								
		Neck	Shoulder	Elbow	Wrist	Upper back	Lower back	Hips	Knees	Ankle
Data entry work	Work experience (Years)	0.343	0.659**	0.285	0.568**	-0.068	0.425*	NR	NR	NR
	Age (Years)	0.178	0.692**	0.321	0.522**	-0.168	0.284	NR	NR	NR
	BMI (kg/m^2)	0.094	0.017	0.299	0.174	0.088	0.092	NR	NR	NR
Parcel sorting work	Work experience (Years)	-0.061	0.362**	0.362**	0.593**	0.502**	0.508**	0.111	0.573**	-0.065
	Age (Years)	-0.022	0.370**	0.477**	0.598**	0.478**	0.376**	0.140	0.480**	0.064
	BMI (kg/m^2)	0.016	0.339**	0.212	0.141	0.086	0.181	0.239*	0.190	0.161
Packaging work	Work experience (Years)	0.138	0.330*	0.287	0.121	0.294	0.152	NR	0.313*	0.265
	Age (Years)	0.092	0.145	0.304*	0.077	0.103	0.346*	NR	0.308*	0.244
	BMI (kg/m^2)	0.095	0.236	-0.024	-0.120	-0.146	-0.026	NR	0.288	-0.179

* $p < 0.05$; ** $p < 0.01$; NR- Not Reported

3.2 Postural Analysis

To conduct a postural analysis for RMS parcel service workers in a simulated work environment, the study used the visual inspection method to record all postures and work activities. The category of work and working postures based on work activities and their risk score are shown in Table 3. For data entry work, there are mainly two types of postures for the activity that were identified through visual inspection method and require further postural analysis in a simulated work environment. Postures for doing the work activities are: typing activity and barcode scanning activity. For parcel sorting work,

there are mainly six types of postures for the activity that were identified through visual inspection method and need to be further analysed through postural analysis in a simulated work environment. Postures for doing the work activities are: taking parcel from primary storage bin, putting parcel on primary sorting table, taking parcel from primary sorting table, putting parcel on secondary storage bin, taking parcel from secondary storage bin and placing parcel on shelf bin. For packaging work, there are mainly six types of postures that for the activity were identified through visual inspection method and need to be further analysed through postural analysis in a simulated work environment. Postures for doing the work activities are: taking parcel from main storage bin, putting parcel on data entry table, taking parcel from data entry table, putting parcel on primary storage bin, taking parcel from shelf bin and placing parcel on packing box.

Table 3: Postural risk scores of RMS parcel hub workers

Category of work	**Sequence of working postures**	**RULA score**	**OWAS score**
Data entry work	1. Typing activity	3	1
	2. Barcode Scanning activity	5	1
Parcel sorting worker	1. Taking parcel from primary storage bin	7	3
	2. Putting parcel on primary sorting table	4	2
	3. Taking parcel from primary sorting table	4	2
	4. Putting parcel on secondary storage bin	7	3
	5. Taking parcel from secondary storage bin	7	3
	6. Placing parcel on shelf bin	4	1
Packaging worker	1. Taking parcel from main storage bin	7	3
	2. Putting parcel on data entry table	3	2
	3. Taking parcel from data entry table	3	2
	4. Putting parcel on primary storage bin	7	3
	5. Taking parcel from shelf bin	4	1
	6. Placing parcel on packing box	3	2

Posture analysis revealed that in data entry work, the highest RULA score was observed for the barcode scanning activity, with a score of 5 (Medium risk), while the OWAS score was 1 (No corrective measures needed). However, due to the higher RULA score (indicating high risk), this posture could be considered as high risk. In sorting work, a RULA score of 7 (Very high risk) was obtained for the posture of taking and putting parcels in storage bins, with an OWAS score of 3 (Corrective measures needed as soon as possible). In packaging work, the RULA score of 7 was obtained for the posture of taking and putting parcels in storage bins, with an OWAS score of 3. These findings clearly indicate that parcel sorting and packaging workers face a high level of musculoskeletal risk based on their RULA scores. To prioritize work based on risk in RMS parcel service operations, sorting should be given the high priority because out of six work postures, three obtained a RULA score of 7, indicating high-risk postures. Then, packaging should have high priority because out of six postures, two postures are high risk with a RULA score of 7. Data entry work should be the last priority as only one posture out of two had a risk with a RULA score of 5. This postural analysis highlights that workers in the Railway Mail Service who handle parcels face a significant amount of musculoskeletal risk, as evident from the postural risk scores.

3.3 Ergonomic Intervention

From postural risk scores obtained through postural analysis with RULA as well as OWAS, it is evident that high risks exist among RMS parcel hub workers. Hence, ergonomic interventions such as modified work procedure and modified work layout has been developed to reduce MSD risk among workers [33].

Modification of work procedure

For make sorting work easier introduced a new procedure with the help of a program, which will reduce manual activity by automation. In the first step 'Add location into MongoDB program' is used to store location details and their corresponding bins in a database called MongoDB. It serves as the initial program for storing the basic details required for bin prediction. Using this program, location and corresponding bins can be accessed and modified at any time. In the second step 'Web-scraping to access location program' accesses the location output of a barcode reader and stores it into a text file. In the last step 'Shelf bin prediction program' predicts the bin number by fetching the location details from the previous text file and retrieving data from the MongoDB database. This program reads the text file 'Location.txt' and retrieves the stored location from that file. After extracting the location, the program takes it as an input. Based on this location input, the program accesses MongoDB, which already stores data about locations and their corresponding bin numbers. Using the location input, the program searches for the location and predicts the bin number.

Modification of work layout

After applying the work procedure, the work activities of sorting workers can be reduced, as they only need to take the parcel and place it directly into the shelf based on the shelf bin number obtained from the program's output. Additionally, the packaging workers are responsible for retrieving parcels placed at a specific height above the ground and positioning them near the fixed barcode reader for automatic scanning. As a result, the workloads of these workers were reduced in the packaging section. Finally, by transforming the barcode reader into a fixed automatic scanning type, the barcode scanning tasks of data entry workers can be further reduced.

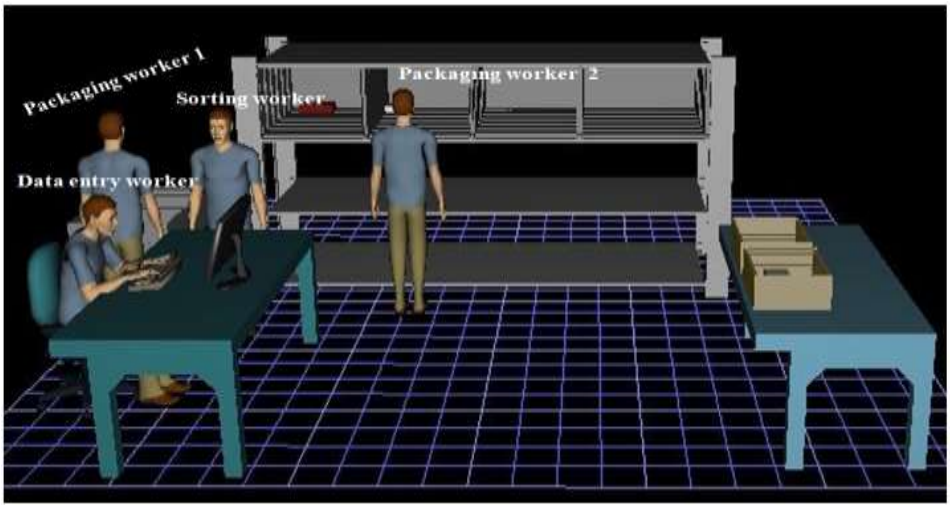

Figure 4: Modified work layout based on intervention work procedure

Modified postures analysis after intervention

The modified work methodology and work layout led to reduce work activities and modify postures of inbound workers in RMS parcel service. The category of work and working postures based on work activities are listed in Table 4. For data entry work, there was only one posture for the activity which is typing activity. For parcel sorting work, there are two types of postures for the activity. Postures for doing the work activities are: taking parcel from primary data entry table and placing parcel on shelf bin. For packaging work, there are four types of postures for the activity. Postures for doing the work activities are: taking parcel from main storage bin, putting parcel on data entry table, taking parcel from shelf bin and placing parcel on packing box.

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Table 4: Postural risk analysis after modified procedure as intervention

Category of work	Working postures	RULA score	OWAS score
Data entry work	1. Typing activity	3	1
Parcel sorting worker	1. Taking parcel from primary storage bin	3	2
	2. Placing parcel on shelf bin	4	1
Packaging worker	1. Taking parcel from main storage bin	4	2
	2. Putting parcel on data entry table	3	1
	3. Taking parcel from shelf bin	4	1
	4. Placing parcel on packing box	3	2

The study conducted by Vishnu et al. [34] analysed the waste sorting task with RULA. It was found that the visual identification and picking task had a RULA score of 4 for the identification of mixed waste, separation and putting waste on a table. No postural improvements were made for these postures since a RULA score of 4 is deemed acceptable to a certain extent. However, in a study by Kumar et al. [35] on the cast house work station, several tasks including placing the core in the core loader got a RULA score of 6, which is an unacceptable level of risk. As a result, an intervention was conducted to reduce the risk, although the resulting RULA score after the intervention was not calculated. These studies pointed out that if the RULA score is less than or equal to 4, the posture is acceptable to an extent, and if the RULA score is greater than 4, an intervention is needed to reduce postural risk. Such an intervention is developed in the present study. The comparison of postural risk scores of the developed intervention with the existing work practices is shown in Figure 5.

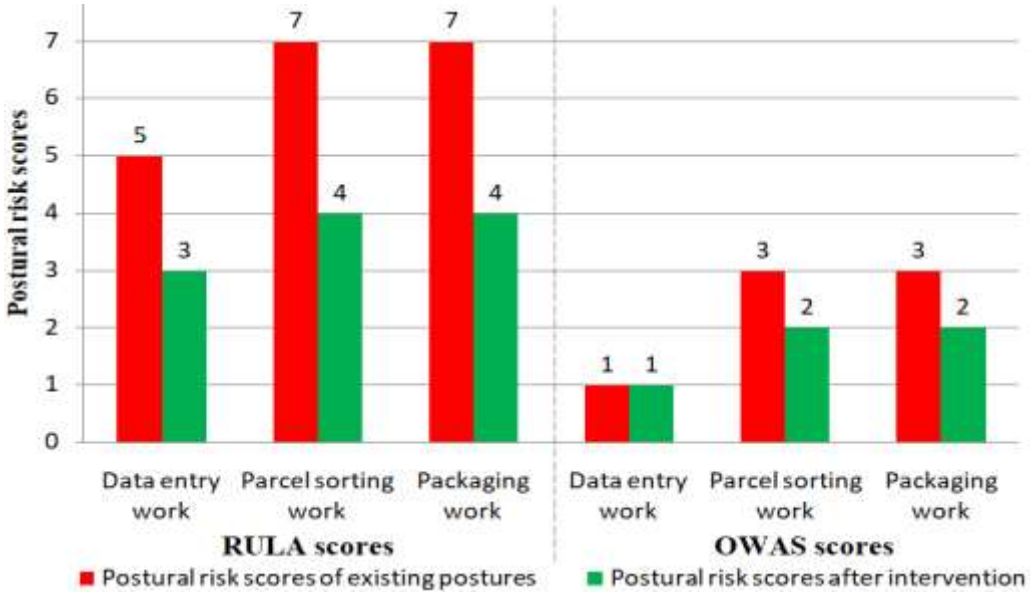

Figure 5: Comparison of postural risk scores of existing postures and after intervention

The postural analysis provides valuable insights into the musculoskeletal risks faced by parcel service workers in RMS. Based on the RULA analysis, it was determined that workers in the parcel service industry who experience upper back pain are at a high risk when performing sorting and packaging work, with a RULA score of 7 (Very high risk), followed by data entry work with a RULA score of 5 (Medium risk). However, the analysis revealed that workers are exposed to unfavourable work postures. The comparison revealed that for data entry work, the higher RULA score in the existing layout postures is 5 and OWAS score 1 (No corrective measures needed) with two work activities, while in the new intervention layout, the RULA score decreases to 3 (Low risk) and OWAS score were 1 with only one work activity for data entry workers. Similarly, for sorting work, the higher RULA score is 7 and OWAS score 3 (Corrective measures needed as soon as possible) in the existing layout

postures, with six work activities, while in the new intervention layout, the RULA score decreases to 4 (Low risk) and OWAS score to 2 (Corrective measures required in near future) with only two work activities for parcel sorting workers. Finally, in packaging work, the higher RULA score is 7 and OWAS score 3 in the existing layout postures, with six work activities, while in the new intervention layout, the RULA score decreases to 4 and OWAS score to 2 with only four work activities for bag opening and packaging workers. This project successfully designed a new work layout with reduced postural risk scores and work activities for all categories of parcel service workers in Railway Mail Service.

4. CONCLUSION

The risk of MSDs among RMS parcel hub workers was identified in this study. The workers were mainly exposed to the risk of MSDs in their upper back and lower back due to their work postures. Data analysis revealed that data entry workers had MSD risks in their wrists, upper back, lower back, and neck, while parcel sorting workers were identified as having a high risk of MSDs in their upper back, shoulder, and lower back regions. However, packaging workers had a risk of MSDs in their lower back, wrist, shoulder, and upper back regions. The postural analysis scores showed that there was a high risk among sorting and packaging workers. New logical work methods and layouts were created to optimize work activities and reduce musculoskeletal risks among the workers in the RMS parcel service hub.

The present study utilized a simulated workplace for the development and analysis of interventions. The intervention was also developed in a simulated work environment. After the implementation of the suggested work practices and workplace changes in the parcel service sector, the effects on reducing MSDs can be verified. Further research is needed to address potential cognitive strain and to ensure the feasibility of implementing the intervention in the parcel service work environment. By measuring the required time for work activities, potential bottlenecks or inefficiencies in the work process can be identified. It will further optimize work activities and reduce the risk of MSDs among the workers.

REFERENCES

[1] Srinivasan, R., & Devi, P. (2015). “An empirical analysis of factors affecting customer satisfaction with parcel delivery services.” International Journal of Logistics Systems and Management, 20(2), 145-163.

[2] Yao, W., Wei, Y., & Huang, Z. (2021). “The Impact of COVID-19 on Last-Mile Delivery Services: Insights from the United States.” Transportation Research Interdisciplinary Perspectives, 10, 100368.

[3] Alghadir, A. H., Gabr, S. A., & Al-Momani, M. O. (2019). “Prevalence of musculoskeletal disorders among Saudi physical therapists: a cross-sectional study.” BMC Musculoskeletal Disorders, 20(1), 65.

[4] Silva, L., Costa, N., & Schutz Rosa, C. (2022). “Ergonomic assessment of postal workers’ pain symptoms and musculoskeletal risks related to parcel processing activity for delivery.” EXCLI Journal, 21,744.

[5] Eshghi, K., & Haughton, G. (2017). “From mail to parcels: The changing role of the postal service.” International Journal of Logistics Research and Applications, 20(6), 523-538.

[6] Eltayeb, S., Ståhl, A., Gao, C., & Mathiassen, S. E. (2019). “Physical work demands and physiological responses in parcel delivery during the holiday season.” Annals of Work Exposures and Health, 63(9), 1105-1114.

[7] Dehghan, F., & Ghasemi, M. R. (2017). "Musculoskeletal disorders and occupational risk factors in the manufacturing sector: A literature review." Health Promotion Perspectives, 7(1), 1-10.
[8] Sekkay, F., Imbeau, D., Dub´e, P. A., Chinniah, Y., de MarcellisWarin, N., Beauregard, N., &Tr´epanier, M. (2020). "Assessment of physical work demand of short distance industrial gas delivery truck drivers." Applied Ergonomics, 89, 103222.
[9] Sekkay, F., Imbeau, D., Dub´e, P. A., Chinniah, Y., de MarcellisWarin, N., Beauregard, N., &Tr´epanier, M. (2021). "Assessment of physical work demands of long-distance industrial gas delivery truck drivers." Applied Ergonomics, 90, 103224.
[10] Shankar, S. K., Kumar, R., Mohankumar, P., & Jayaraman, S. (2017). "Prevalence of work-related musculoskeletal injuries among South Indian hand screen-printing workers." Work-a Journal of Prevention Assessment Rehabilitation, 58(2), 163–172.
[11] Chao, C., Chen, M., & Yau, Y. (2018). "Prevention of work-related musculoskeletal disorders in a chemical plant in Taiwan and a comparison of three assessment tools." Human Factors and Ergonomics in Manufacturing Service Industries, 28(5), 238–249.
[12] Sweity, K., Abu Shaban, A., & Sweity, H. (2019). "Risk factors for lower back pain among male factory workers in Gaza Strip." Eastern Mediterranean Health Journal, 25(2), 95-101.
[13] Mishra, A., & Gupta, A. (2019). "Parcel traffic in Indian Railways." Journal of Rail Transport Planning & Management, 9, 57-69.
[14] Singh, S., & Jaiswal, A. (2021). "Railway Mail Service (RMS) Operations in India: A Review." Proceedings of the 3rd International Conference on Computing Methodologies and Communication, 205-212.
[15] Sauter, S.L., Schleifer, L.M. & Knutson, S.J., 1991. Work posture, workstation design, and musculoskeletal discomfort in a VDT data entry task. Human factors, 33(2), 151-167.
[16] Yadav, H., Bhattacharya, A., & Mohapatra, S. (2020). "Prevalence of musculoskeletal disorders and risk assessment among workers engaged in parcel sorting in courier and logistics companies." Indian Journal of Occupational and Environmental Medicine, 24(2), 92-98.
[17] Azizah, F., Muflih, S. M.,& Husna, M. (2021). "Prevalence and risk factors of musculoskeletal disorders among manual material handling workers in a manufacturing company in Indonesia." International Journal of Occupational Safety and Health, 11(2), 107-114.
[18] Deros, B. M., Daruis, D. D. I., Ismail, A. F., Sawal, N. A.,& Ghani, J. A. (2010). "Work-Related Musculoskeletal Disorders among Workers' Performing manual material handling work in an automotive manufacturing company." American Journal of Applied Sciences, 7(8), 1087–1092.
[19] LeBaron, E., Smith, A., Welch, L., Huang, E., & Arsenault, R. (2017). "Musculoskeletal Symptoms and Ergonomic Risks Among US Postal Service Mail Carriers and Clerks." Journal of Occupational and Environmental Medicine, 59(9), 892-897.
[20] Kuorinka, I. a. A., Jo¨nsson, B., Kilbom, ˚A., Vinterberg, H., Biering-Sørensen, F., Andersson, G., &Jørgensen, K. A. (1987). "Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms." Applied Ergonomics, 18(3), 233–237.
[21] Zhang, Y., Wu, X., Gao, J., Chen, J., & Xv, X. (2019). "Simulation and Ergonomic Evaluation of Welders' Standing Posture Using Jack Software." International Journal of Environmental Research and Public Health, 16(22), 4354.
[22] McAtamney, L., & Corlett, E. N. (1993). "RULA: a survey method for the investigation of work-related upper limb disorders. Applied Ergonomics," 24(2), 91–99.
[23] Karhu, O., Kansi, P., &Kuorinka, I. (1977). "Correcting working postures in industry: A practical method for analysis." Applied Ergonomics, 8(4), 199–201.
[24] Scott, G., &Lambe, N. (1996). "Working practices in a perchery system, using the OVAKO Working posture Analysing System (OWAS)." Applied Ergonomics, 27(4), 281–284.

[25] Smith, J., Johnson, A., & Davis, M. (2022). "Ergonomic factors contributing to musculoskeletal disorders among data entry workers." Journal of Occupational Health and Safety, 10(3), 123-137.
[26] Warnakulasuriya, S. S. P., Peiris-John, R., Sivayogan, S., & Sathiakumar, N. (2012). "Work-related Musculoskeletal Disorders among Mail Sorting Officers in Sri Lanka: a Cross-Sectional Study." Journal of the College of Community Physicians of Sri Lanka, 7(1), 43-50.
[27] Levanon, Y., Gefen, A., Lerman, Y., Givon, U., & Ratzon, N. Z. (2012). "Reducing musculoskeletal disorders among computer operators: comparison between ergonomics interventions at the workplace." Ergonomics, 55(12), 1571–1585.
[28] Sasikumar, V., & Binoosh, S. A. (2018). "A model for predicting the risk of musculoskeletal disorders among computer professionals." International Journal of Occupational Safety and Ergonomics, 26(2), 384–396.
[29] Motamedzadeh, M., Jalali, M., Golmohammadi, R., Faradmal, J., Zakeri, H. R., &Nasiri, I. (2021). "Ergonomic risk factors and musculoskeletal disorders in bank staff: an interventional follow-up study in Iran." The Journal of the Egyptian Public Health Association, 96(1).
[30] Rahman, M. N. A., & Zuhaidi, M. F. A. (2017). "Musculoskeletal symptoms and ergonomic hazards among material handlers in grocery retail industries." IOP Conference Series, 226, 012027.
[31] Zhao, Y., Jaafar, M. S., Mohamed, A. F., Azraai, N. Z., & Amil, N. (2022). "Ergonomics Risk Assessment for Manual Material Handling of Warehouse Activities Involving High Shelf and Low Shelf Binning Processes: Application of Marker-Based Motion Capture." Sustainability, 14(10), 5767.
[32] Anton, D., & Weeks, D. L. (2016). "Prevalence of work-related musculoskeletal symptoms among grocery workers." International Journal of Industrial Ergonomics, 54, 139–145.
[33] Das, B., & Sengupta, A. (1996). "Industrial workstation design: A systematic ergonomics approach." Applied Ergonomics, 27(3), 157–163.
[34] Vishnu A. A., Siddaveeraiah K. S., Rahul K. V & Nirmal S., Thalor, P., Sultana, S., Emmatty, F. J., & Panicker, V.V. (2019). "Observation-based Postural Assessment of Waste Sorting Tasks." Proceedings of IEEE International Conference on System, Computation, Automation and Networking, 1-6.
[35] Kumar, G. S., & Das, A. (2012). "Analysis and ergonomic improvement of working postures in cast house work station using JACK modelling. International Journal of Human Factors Modelling and Simulation, 3(1), 16-31.