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A Case Study of Ergonomics Prevention Program in a Machine Manufacture Industry

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Abstract

Musculoskeletal Disorders (MSDs) is the most potential risks in human production and economic systems. In this research, ergonomics guidelines and enacted relevant regulations announced by other countries to effectively facilitate ergonomics prevention programs were discussed. A machine manufacture industry as a case study has been ergonomically evaluated by Musculoskeletal Disorders Checklist (MSDs) and Nordic Musculoskeletal Questionnaire (NMQ), which was used to recognize the dominating risk factors. According to the result of observation and preliminary assessment, low back pain related to the high frequency of manual material handling tasks was the critical issue in this case study. The conclusion revealed that the proposed improvement such as engineering redesign, training, health management, and administration, would be implemented into the main axle assembly area, customer service department, and Z-axis assembly area. The further improvement interventions would help organization to carry out the ergonomics prevention program.

Keywords: *Ergonomic, Musculoskeletal Disorders (MSDS), Evaluation, Manual Materials Handling (MMH)*

INTRODUCTION

Musculoskeletal Disorders (MSDs) is the most potential risks in human production and economic systems. Since it does not have immediate and visible negative effects on human health, such as fire, explosion, poisoning, falling, etc.; however, repetitive movements and cumulative fatigue in various daily operations and tasks for workers, causing a gradual stacking of losses to workers' personal and productivity. Unfortunately, influencing a significant damage that is difficult to recover and irreversible. Therefore, it is listed as a topic of high concern in global economic institutions and labor organizations.

Burdorf (2010) indicated that ergonomics intervention was the significant and effective approach in preventing MSDs showed in most scientific literatures. Takala (2010) illustrated that the purpose of ergonomics intervention was to redesign the workstation and process to enhance the performance of organization, such as health, safety, and productivity. Therefore, Colim (2020) and Sriyogi (2014) applied ergonomics evaluation and improvement in industrial assembly workstations and steel and power industry as case studies, respectively.

LITERATURE REVIEW

The issues of concern to the management of the business unit range from the overall aspect of the enterprise to the implementation aspect, namely, the improvement of production efficiency, the creation and improvement of corporate image, the coordination of order acquisition and customer demand, the reduction of production costs and the improvement of quality. The promotion of the ergonomics prevention plan must be closely linked with these issues of concern to the management of the business unit, to enhance the willingness and effectiveness of the implementation of the prevention plan from a more proactive and forward-looking perspective. Therefore, many countries have announced guidelines even enacted relevant regulations and laws to effectively facilitate ergonomics prevention programs.

OSHA (Occupational Safety and Health Administration) recommends that employers could organize improvement teams within the enterprise, through internal training and with the provision of improvement cases, to help employees establish ergonomic risk awareness, so that they could detect the

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problems of the current operating methods, provide feasible improvement methods, and start to implement practical solutions. In addition to traditional occupational safety and health requirements of legality, compliance, and reasonableness, this approach is more forward-looking because it combines elements such as corporate operational performance, productivity improvement, and employees' future careers with occupational safety and health. More benefits could be obtained by preventing the hidden ergonomic risks.

In the practice of HSE (Health and Safety Executive) in the United Kingdom and the Ministry of Health, Labor and Welfare in Japan, it could be found that in addition to the basic principles of administration and field, both focus on the importance of implementation. The HSE does not design additional propaganda materials, but instead used practical cases to publicize the risk of low back pain and current preventive practices. In Japan, the circular quality management PDCA (Plan, Do, Check, and Act) activities are introduced on the spot, improvement methods to reduce the risk of low back pain in the workplace are developed and implemented, eventually, a more complete occupational safety and health management system is built.

NIOSH, the American Institute for Occupational Safety and Health, published a "NIOSH Strategic Plan: FYs 2019–2023," which illustrates changes in industry development have a significantly impact on the work and labor. Manufacturing is one of the seven industries which are the most likely to cause MSDs as identified in this strategic plan. The introduction of mechanization and automation on the shop floor has changed the nature of manufacturing job demands, but lower back pain and upper extremity remain the most common musculoskeletal injuries suffered by manufacturing workers. Employee fatigue could be reduced by implementing advanced equipment such as robotics, exoskeletons and sensor measurements, but the lack of technology to use emerging technologies in the industry could present potentially unforeseen dangers in the manufacturing process.

National Occupational Safety and Health Profile of Taiwan has developed and introduced “Ergonomics Prevention Guidelines for Musculoskeletal Disorders” through ergonomic intervention and research studies of MSDs risk prevention for workplace improvement programs for many years (OSH, 2014). Manufacturing is an important economic industry in Taiwan. As a result, in this research, a case study of ergonomics prevention program was carried out in the manufacturing plant of a Computer Numerical Control machining company.

The objectives of this study was to ergonomically assess the key stations in the manufacturing shop floor and the recommendations were provided to improve the workplace.

RESEARCH METHODOLOGY

One of the most flexible or available research designs and methods is the case study, researchers could discover the empirical events, furthermore, maintain the meaningful and holistic characteristics of real circumstances (Yin, 1989). Therefore, the case study discussed in this paper would focus on intensive and holistic description and analysis.

This ergonomics prevention program included three stages as follows. Firstly, on-site observation of the workstations which existed potentially ergonomic risks indicated by the department of health, safety, and environment (HSE) department of this business case and an external ergonomics consulting expert team. Secondly, ergonomic assessment through Nordic Musculoskeletal Questionnaire (NMQ) developed by the Nordic Council of Ministers to all operators and MSDs Checklist (OSHA, 1995) to observed workstations evaluated by ergonomics experts. NMQ is a self-reported standardized questionnaire with a body map including neck, shoulders, upper back, elbows, low back, wrist/hands, hips/thighs, knees and ankles/feet. Respondents will identify areas of the body causing musculoskeletal symptoms in the last 12 months excluding normal activities. The aim of MSDs checklist (OSHA, 1995) is to recognize the ergonomics risk factors, which may induce the development of MSDs, including exerting excessive force, repetitively performing the same or similar tasks and movements, working in awkward posture or being in the same posture without enough rests during a long time, pressing the body part against hard or sharp edges, cold condition, vibration, and combined exposure to multiple risk factors. Finally, ergonomic recommendations were provided to prevent and control the potential problems or injuries.

FINDING AND DISCUSSION

Descriptions and preliminary assessment for three regions were observed and illustrated as follows.

A. Current status description

1) The first observed region was the main axle assembly area with the following three steps.
   a) Assembly: Lift overhead unassembled parts with 30~40 kg then aligns them to the center.
   b) Combination: Put the assembled part into the barrel through the overhead crane. The total weight of the packaged parts is about 60~70kg, and the bulk parts are more than 100kg.
   c) Calibration: The operator, who is usually in a squat or bend posture, use a hand tool, such as a hammer, for alignment correction. Because there is a specification tolerance between the assembled part and barrel, the assembled part could not be accurately fitted into the barrel at times. It is not suitable to adjust the height of the work surface due to the different requirement for the three steps.

2) This case company is capable of turnkey solutions, which designs and produced every component from the initial machine planning to the final machine processing. The after-sales service, such as replacement and maintenance of all parts, is the function to the department of customer service, which was the second observed region.
   a) Pick-up area: According to the customer needs, the weight and shape of the replacement parts are diverse. The weight of a single piece is from 1 to almost 200 kg, and its average weight is 40 kg. Each operator handles the total loading per day is about 200 kg.
   b) Package area: The operator manually handles and place the goods on a workbench, then bundle and package them by tape, thin or thick and wide plastic material. Since the shape of object is in a variety, such as the cuboid, barrel, and cylindrical parts, it might induce further ergonomic problems. The thinner and harder yellow straps are used to fix for the cuboid parts, and the straps are tightly bounded to the parts. The contact area between the strap and the hand is too small, and it is not easy to take it. The barrel parts are large and difficult to turn over. The center of gravity of the cylindrical part is not fixed for rolling over to package, and it may cause the hand radial/ulnar deviation.

3) The third observed region is the Z-axis assembly area. The operator packs 20 pieces per wooden box which weighs around 20kg, and the average handling loading is 2 boxes per day. Because the volume of the parts is large and need to be vertically pulled upwards from the bottom, most operators suffered low back pain during lifting.

B. Preliminary assessment

The major characteristics of three observed manufacturing areas were mainly standing position and manual material handling. The MSDs evaluation result with relevant parts was shown in Table 1. The final result score of MSDs checklist higher than 6 points reveals the high potential ergonomics risk. The main axle assembly and customer service areas belong to higher ergonomics risk workstation which MSDs score is higher than 8 points; and the Z-axis assembly area belong to high ergonomics risk workstation which MSDs score is from 6 to 7 points. Therefore, all of them had potential ergonomics risks and the ergonomics improvement measures were needed to be implemented.

Table 1 MSDs evaluation result

No.	Workstation	Back and lower limbs					Manual material handling			Total
		Awkward posture				Sub-total	Distance and Weight	Number of Times	Sub-total	
		Side Bend	Lean forward	Lean back	Turn around					
1	Main axle	1	2		1	4	5	2	7	11
2	Customer service	1				1	5	2	7	8
3	Z-axis	1				1	3	2	5	6

Based on NMQ questionnaire, which was carried out in the medical examination by the case company last year, each part of the body was subjectively rated from 1 (mild) to 5 (serious) in terms of fatigue level as shown in Figure 1. Overall, most of the employees did not have any significant uncomfort during the workday. The result indicated that most employees could stand the current workload.

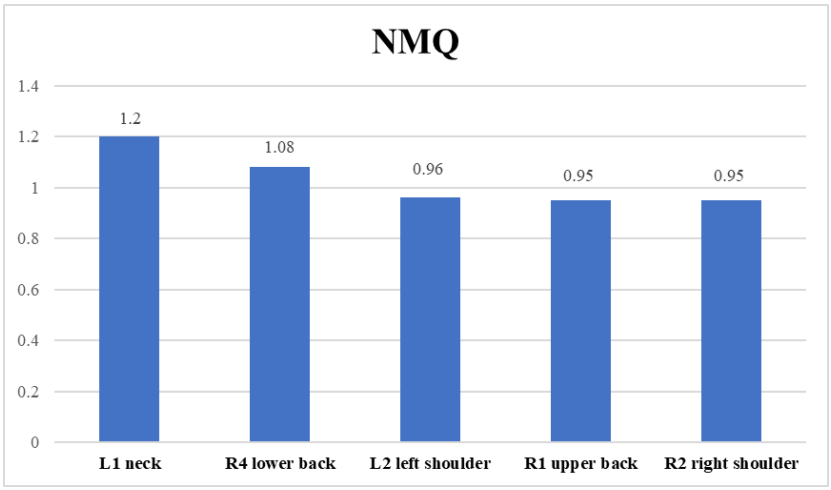

Figure 1. The result of NMQ of medical examination

CONCLUSION AND FURTHER RESEARCH

In this research, although NMQ result showed that the employees' subjective response to workload was not significantly uncomfortable in the three observed manufacturing areas, MSDs outcome existed potentially high ergonomics risk, which might lead to ergonomics problems. Especially the low back pain associated with the high frequency of the most manual material handling tasks.

Based on the outcome of observation and preliminary assessment, the proposed corresponding comments were as follows.

A. Engineering redesign
1) Main axle assembly area: The desktop adjustable three-axis fixing device for improving the precision of parts assembly was recommended to involve, and thus reduce the frequency of squat and bend postures.
2) Customer service department:
    a) For barrel-shaped or column-shaped goods, a roll, which the appearance is like a kitchen napkin standing, was suggested to implement in the packing area to fix the sides of the goods to reduce the radial and ruling movements caused by the hand grip of the personnel.
    b) For cylindrical-shape goods, a movable basket type grip could be used to increase the contact area between the hands and the objects to make it easier to take.
    c) Re-layout in this area might reduce the distance and time of transportation.
3) Z-axis assembly area: The workload for the horizontal lifting is less than that for the vertical lifting. As a result, the Z-axis fixed seat was suggested to change and shift by 90 degrees, so that the objects were placed parallel to the bookcase and taken out to reduce the lifting height of the hands

B. Training: Health promotion seminars will be arranged for employees to establish proper knowledge of health risks.
C. Health management: To perform special physical or health checkups for health operations of ergonomics risks, especially for high-risk personnel, and to establish health management database for tracking. The organizations with more high-risk personnel need to carry out specific ergonomics projects for improvement.
D. Administration: The company internal ergonomics guidelines need to be developed.

The further ergonomics intervention progress check approaches would be facilitated by an internal dedicated ergonomics team, which including related departments, such as industrial engineering,

manufacturing, product design, and so on. It would help organization to ensure the outcome of the ergonomics prevention program.

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REFERENCES

Anderson SE, Meade BJ (2014). Potential health effects associated with dermal exposure to occupational chemicals. Environ Health Insights 8 (Suppl 1):51-62

Burdorf, A (2010). The role of assessment of biomechanical exposure at the workplace in the prevention of musculoskeletal disorders. Scand. J. Work. Environ. Heal. 36: 1–2

Cashman MW, Reutemann PA, Ehrlich A (2012). Contact dermatitis in the United States: epidemiology, economic impact, and workplace prevention. Dermatol Clin 30(1):87-98, viii.

Colim, A.; Faria, C.; Braga, A.C.; Sousa, N.; Rocha, L.; Carneiro, P.; Costa, N.; Arezes, P. (2020) Towards an Ergonomic Assessment Framework for Industrial Assembly Workstations—A Case Study. Appl. Sci. 10: 3048

Kottala, Sriyogi. (2014). An Ergonomic Evaluation of Work Place in Steel and Power Industry - A Case Study. National Conference on Industrial Engineering and Technology Management.

NMQ: Kuorinka I, Jonsson B, Kilbom A, et al. (1987). Standardized Nordic questionnaires for the analysis of musculoskeletal symptoms, Applied Ergonomics 18: 233-237

Takala, E.-P., Pehkonen, I., Forsman, M., Hansson, G.-A., Mathiassen, S.E., Neumann, W.P., Sjøgaard, G.,

Veiersted, K.B., Westgaard, R.H., Winkel, J. (2010) Systematic evaluation of observational methods assessing biomechanical exposures at work. Scand. J. Work. Environ. Heal. 36: 3–24.

The National Institute for Occupational Safety and Health (2021), NIOSH Strategic Plan: FYs 2019–2024, https://www.cdc.gov/niosh/about/strategicplan/

Yin, R.K. (1989), "Case Study Research: Design and Methods, Sage Publications, London.