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REBA AND RULA ERGONOMIC RISK ASSESSMENTS OF OPERATORS IN A MAINTENANCE AND REPAIR WORKSHOP OF A TEXTILE FACTORY

Dilara MUHACIR, Muhammed İdris AKTAŞ, Eren ÖZCEYLAN

Abstract: *This study includes the determination of the skeletal and muscular system disorders occurring in the operators working in the maintenance and repair department of a textile company that requires labor intensive operations. To determine the risk scores for the jobs performed by the operators in the maintenance and repair unit, REBA and RULA approaches are applied. As a result of the studies, it was decided to apply the mechanical parts in place in a way that minimizes the risk levels as improvement suggestions for clamping, milling and turning operations that require urgent intervention. It is planned to apply the study in the future periods with various ergonomic evaluation methods in departments other than the maintenance and repair unit.*

Key words: *musculoskeletal disorders, REBA, RULA, occupational risk, intervention.*

1. INTRODUCTION

Today, with the development of technology, the need for manpower, which is one of the most basic production factors, has decreased, especially in production areas, and has been replaced with automated systems [1]. The simplification and autonomy of operations and systems in general in production and service areas, which increase its impact day by day with Industry 4.0, has enabled the manpower involved in production to work under more favorable conditions [2].

In our modern world, automatization in production areas continues to replace conventional systems at a rapid pace. Automatization activities are progressing very slowly in Turkey, especially in enterprises operating in the field of textile [3]. This situation causes the working environment and conditions of manpower to be under more difficult conditions [4].

The fact that the human power, which is very important in production efficiency, works in negative and risky conditions causes skeletal and muscular system disorders [5]. Therefore, the work to be done by manpower should be carried out under ergonomic conditions [6].

In companies, the maintenance-repair unit, which is a department where the human factor has a great impact on the emergence of the final product, works intensively and includes quite a variety of operations [7]. When the processes taking place in the maintenance-repair unit and the conditions for the operators to perform the work are examined, it has become a very critical situation to make ergonomic evaluations [8].

When we look at ergonomic evaluation methods in the literature, studies in different fields with REBA and RULA methods, which are widely used, draw attention.

Hignett and McAtaney [9]'s study includes ergonomic evaluations of the working conditions of nurses. The aim of the study is to determine the risk status of the unpredictable working situation of the health workers. It is understood that more situation analysis is needed to ensure its validity. When we look at the studies carried out with REBA in the production processes, a sample application of

the REBA method was made in the production line and a decrease was observed in the REBA risk score with the suggested improvements for the results obtained in the study by Tarakçı et al. [10]. Another study [11] conducted with REBA analyzed the postures of people who repair and design computers using the REBA method. When the studies in the field of maintenance and repair are examined, the risky operations caused by the postures of the operators working in the maintenance unit were determined using the REBA method in the study by Am-Eam et al. [12].

When the studies on RULA were examined, it was found that the study by Nahavandi and Hossny [13] investigates the utilization of Kinect sensors for real time RULA to aid in ergonomic analysis for assembly operations in industrial environments (similar approaches as presented in [14, 15]).

In addition to the studies with various examples in the literature, within the scope of this paper, the stances taken by the operators working in the maintenance and repair unit of the Boyar Kimya Tekstil factory, which produces and dyes acrylic yarn in Turkey, were analyzed. In the evaluations made, unlike a conventional method, a questionnaire was conducted with the human anatomy poster given to the operators working in the maintenance and repair unit, whether they were exposed to any skeletal musculoskeletal disorders during or after the work. As a result of the survey data obtained, the method that will ergonomically evaluate the posture movements of the operators working in the maintenance-repair unit in the best way has been selected. It was decided that REBA and RULA would be the most appropriate evaluation methods for operators' stances. By using two different evaluation methods together, the risks that the operator is exposed to have been evaluated from a broad perspective. In this way, attention was paid to the skeletal and muscular system health, which could threaten the skeletal and muscular system of the human factor and cause permanent disorders in the following periods, and it was aimed to make the working environment of the manpower, which should work with optimum efficiency in a labor-intensive factory, more favorable.

The ergonomic evaluation methods carried out within the scope of this study were carried out in four stages. In the first stage, the working conditions of the operators working in the maintenance-repair unit were examined. In this way, the determination of the problems that come across operators during and after the operation was made with a survey. In the second and third stages of the study, there are applications of REBA and RULA methods, which are ergonomic evaluation methods selected by evaluating the physical strains of the body parts according to the posture of the operators. The last stage of the study is the part where the results of REBA and RULA methods are evaluated. In this section, one of the suggested improvement activities is to make changes in the position of some parts in the machines for the milling, turning, and clamping operations from the four basic operations that take place in the maintenance-repair unit. The details of the four phases are covered in the Case Study section of this study.

When the studies in the maintenance and repair units of textile companies are examined in national and international studies, it has been understood that the most frequently used ergonomics evaluation methods in this field are REBA, RULA, and OVAKO Working Posture Analysis System (OWAS). In this study, unlike other studies in the literature, statistical problem detection method with a questionnaire was used to determine the problem that occurred. Considering the problem that occurred and the working conditions of the operators, it was decided to use the REBA and RULA methods, and ergonomic evaluation was made with the visuals of the operations that occurred, unlike most studies.

In the last part of the study, in which REBA and RULA, which are ergonomic evaluation methods for the solution of a real problem, are applied, then the study is concluded where the general evaluation is made.

2. METHODOLOGY

Operators working in production areas have both physical and mental work intensities and loads within the framework of the work they do. The starting and most basic point of getting

efficiency from the work done are that the way the work is done is designed very well [16].

When the studies carried out in recent years are examined, especially repetitive work that is not done ergonomically has a great effect on operators both physically and psychologically. When we look at the types of occupational accidents, it is understood that skeletal and muscular system disorders are the most common [17].

Considering the problems that the work process or operation will cause because of all kinds of burdens on the employee, aiming to reduce the risk that may occur or already occur, the process of designing the system will be provided with ergonomic evaluations [18].

Ergonomics has been defined by the International Ergonomics Association as "the understanding of the interaction between the elements and people of a system and the professional scientific discipline that applies theory, principles, data, and methods to design" [19].

The goal of ergonomics is to ensure that the work is compatible with people and also is done efficiently and reliably. Anthropometric data are used in ergonomic evaluations and designs. Anthropometric data is the numerical evaluation of body height and characteristics of individuals according to their region and nationality. The concept of nationality and region, which is valid in the numerical expression of body proportions, arises from the fact that environmental and hereditary characteristics play a role in the morphological evaluation of people. For this reason, anthropometric data should be used for the workplace to be designed in an ergonomic way [20].

Different measurements and methods are used to make ergonomic evaluations. It is necessary to understand the intensity of the work to which the operator is exposed or how much the load is at which points [21].

Considering the ergonomic risk assessment methods, RULA (Rapid Upper Limb Assessment), NIOSH (National Institute for Occupational Safety and Health), REBA (Rapid Entire Body Assessment), OWAS (Ovako Working Posture Analysing System), and LMM (Lumbar Motion Monitor) are used. Ergonomics is one of the evaluations methods [22].

The selection of the method to be used is based on the body parts and movements to be evaluated. In the algorithm below, the usage cases of the three most used different methods from ergonomic evaluations are schematized (Figure 1). In this study, when the performance of the operators of a textile company engaged in yarn production and dyeing was evaluated, it was understood that the operators working in the maintenance and repair unit had skeletal and muscular system disorders.

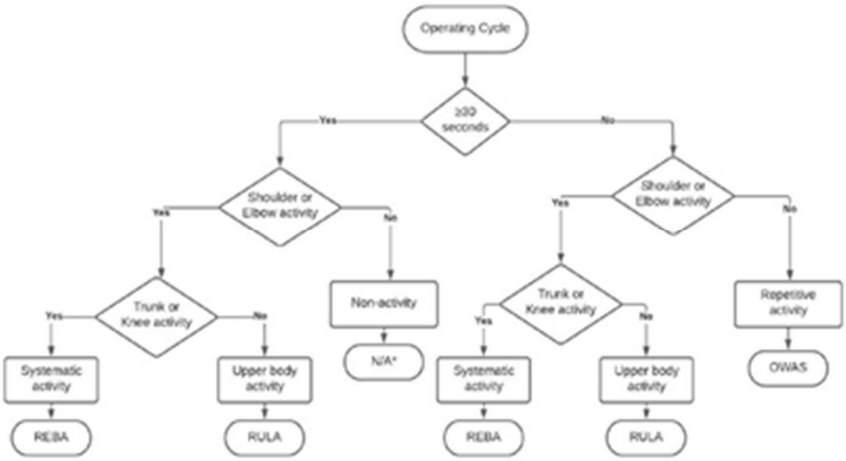

Fig. 1. Diagram of ergonomic assessment methods.

As a result of the survey conducted separately for the operators working in this unit, it was understood that the operators working in the maintenance and repair unit were uncomfortable

with the common body parts. The questionnaire required to make this determination is given in Figure 2.

As a result of the determined data, when the national and international literature studies are examined, it is understood that there are ergonomic evaluation methods that vary according to the body parts of the operators affected by the work done. In this study, unlike the studies in the literature, the scope of ergonomic evaluation, which is made by using more than one method at the same time, has been expanded.

Two of the selected REBA and RULA ergonomics evaluation methods are applied to the welding, clamping, milling and turning processes in the maintenance and repair unit, and the risk levels are given in the tables together with their visuals (Figures 3 to 9).

2.1 Rapid Entire Body Assessment (REBA)

It is an ergonomic evaluation method in which the risk rating of the damage caused by the physical load that occurs due to the posture positions of the human body is made. With this method, risk points are given to the physical load that occurs on the neck, trunk, legs, arms, and wrists during the work of the human body, and actions are recommended.

In the REBA application, points are assigned according to the stance of the operator while performing the work, for the limbs specified in the A and B tables. In addition to the A table score; an additional score is assigned according to the load-bearing status of the neck, trunk, and legs. The same is done by adding the gripping score to table B.

After the A and B scores are completed, the resulting risk scores are assigned to table C. The REBA score is found by adding the activity intensity score to the C risk score obtained.

2.2 Rapid Upper Limb Assessment (RULA)

One of the most common ergonomics methods is RULA. RULA is a method developed by Corlett and McAtamney to obtain the degree of risk determined by considering the human skeletal and muscular system of the physical load occurring on the upper arm, lower arm, wrist, neck, trunk, and legs of the operator performing the work. The application steps of the RULA method are similar to REBA. The first step in the RULA method is to obtain the A score. The body parts rated by the A score are the lower arm, upper arm, and wrist. Neck, trunk, and limbs constitute the evaluation criteria required for obtaining the B score. The situation exhibited by the operator while performing the job is analyzed, and the scores are marked in the table, respectively, and the intersection point is expressed as the B table score. In obtaining the C table score, which is the last stage of the RULA method, the intersection points of the scores of the A and B tables are taken from the table and the RULA ergonomic risk rating score for the selected operation is determined.

3. CASE STUDY

In this section, ergonomic evaluations of the operators working in the maintenance and repair unit were made with REBA and RULA. The study was carried out to find a solution to a real problem. Ergonomic evaluation stages and results are given in the subsections.

3.1 Description

The place where improvement suggestions are made by using REBA and RULA ergonomics risk assessment methods is the maintenance and repair workshop of a textile company in Turkey that produces and dyes synthetic yarn. It includes the ergonomic analysis of the postures of the operators working in the maintenance and repair unit while performing the milling, turning, clamping, and welding processes.

The maintenance and repair unit is the team responsible for the maintenance and repair of machinery and equipment in operation. In the maintenance and repair workshop, there are welding, milling, turning, and drilling machines for the repair of machinery and equipment. In this unit of the factory, a total of 12 people work in three shifts.

3.2 Identification of Physical Problems

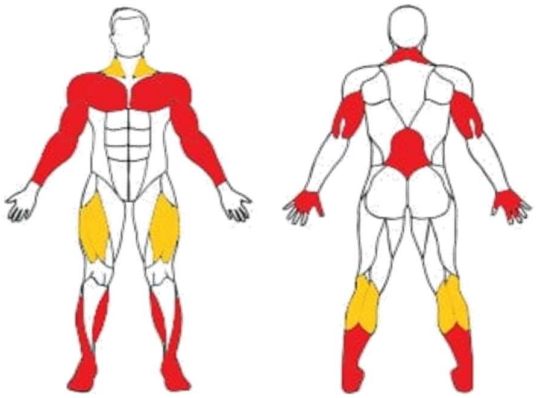

Fig. 2. The body map of pressure and pain.

Skeletal musculoskeletal pain caused by operators' posture while performing milling, turning, clamping and welding operations were investigated. At this stage, a schematic image of human body parts (Figure 2) was given to 12 operators working in three shifts. The operators were asked the question of which parts of their bodies the pain occurs during or after the work. The answers given by the operators are independent of each other. The proportions of the answers obtained are illustrated in Figure 2.

When the answers given by the operators were examined, the parts in red are the parts that the operators describe as moderate intensity and it is 86%. The parts indicated in yellow are the areas defined by the operators as mild pain. The rate of mild severe pain is around 4%. There is no pain defined by the operators as severe pain.

3.3 REBA and RULA Application

In this section, the analyses of the operators' stop during the milling, clamping, turning and welding processes during the machining of the part are made using REBA and RULA methods. In the Figures 3 to 12 given below, the risk ratings are obtained by using the images showing one or more operation steps for each transaction.

Welding Process: It is the process of joining two parts. REBA and RULA methods were made by recording and examining the methods which were applied. The REBA and RULA risk levels of the welding process are given in Fig. 3 below.

Clamping Process: It is the process in which the operator clamps the work piece and fixes it as desired. The process has sub-processes. The processes whose risk scores for the clamping procedure are determined according to the REBA and RULA methods are given in Figures 4 to 7.

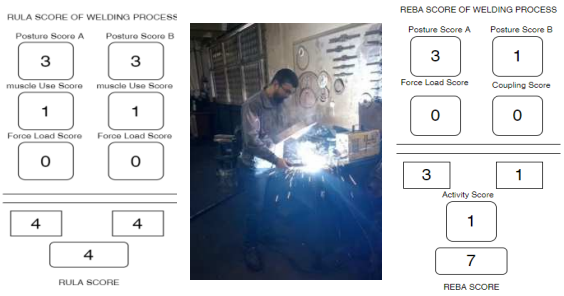

Fig. 3. Risk score of the welding process.

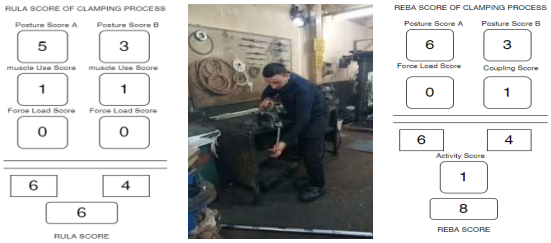

Fig. 4. Risk scores of turning the product on the clamping process.

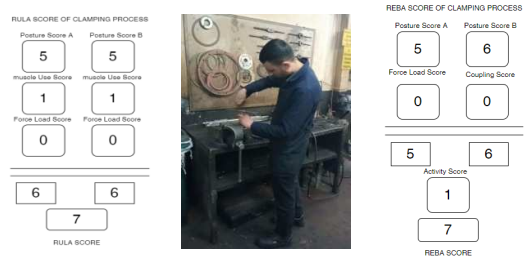

Fig. 5. Risk scores of the clamping process.

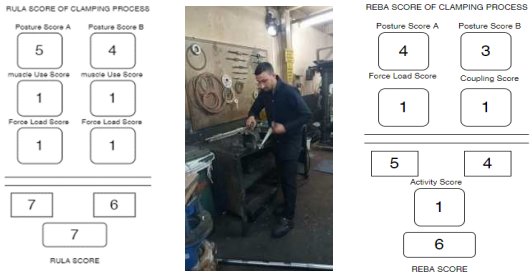

Fig. 6. Risk scores of clamping process while the operator applies force.

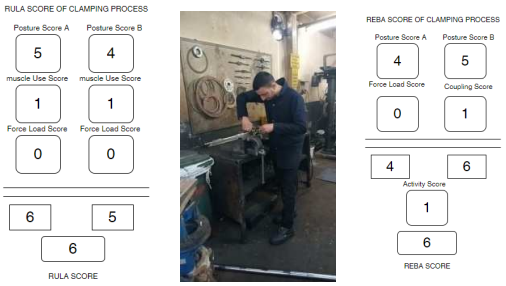

Fig. 7. Risk scores of clamping processes while the operator turnings the product by force.

Fig. 8. Risk scores of the milling process.

Fig. 9. Risk scores of milling processes while the operator is bending over.

Turning Process: It can be defined as a workbench that gives the desired shape by giving rotational movement to the workpiece and continuously removing chips with a cutting tool. The results of turning process are shown in Figures 10 to 12.

Milling Process: It is the process in which the operator fixes the work piece and then drills. During these operations, the operator must adjust the work piece. The results are shown in Figures 8 and 9.

3.4 Results and Recommendations

Suggested improvements with the data obtained because of ergonomic evaluations.

In clamping operation, it is necessary to turn the arm by applying a force by the operator to process the part.

The RULA risk level obtained when the operator performs this operation frequently and for long periods is 7 (High risk), and it is known that it will cause serious skeletal and muscular system disorders. To prevent this situation, it is suggested to use a power transmission system that will be mechanically designed. In this way, there will be a reduction in the amount of power required to cycle the machine part.

Fig. 10. Risk scores of the turning process.

Fig. 11. Risk scores of turning process while the operator presses the button.

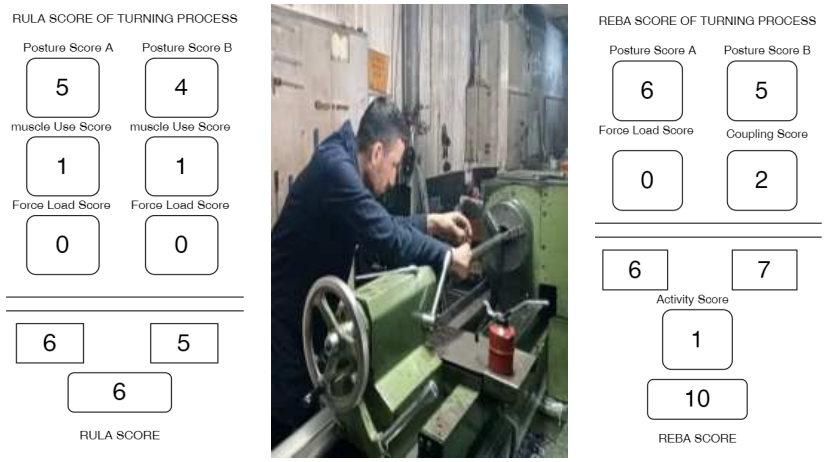

Fig. 12. Risk scores of the turning adjustment.

Another improvement activity needs to be applied to the milling operation. The risk level in the milling operation is 9 (high risk) for REBA and 5 (medium risk) for RULA.

These scores proved that the limbs evaluated in the REBA method are highly under the influence of physical load. The operator must uncontrollably bend and apply force during the milling process and cycle to adjust the machine. When the research and the machines available in the market are examined, it has been suggested that the cycled apparatus should be positioned upwards so that it will not burden the operator's waist for this operation that is required for the adjustment of the machine and that the operator does while each part is being processed.

In the turning process, the score level of the load that the operator is exposed to while performing the operations is 9 (high risk) for REBA and 6 (medium risk) for RULA. Considering the current state of the machine, its location, and the operator's posture, the first recommendation is to move the start button located at the bottom of the machine until the operator presses the button without bending over during the operation. Another suggestion is to lift the machine until it reaches a level where the operator does not have to go into a bending position while working on the part.

4. CONCLUSION

Within the scope of this study, the postures of the operators working in the maintenance and repair unit of a textile company engaged in the production and dyeing of synthetic yarns were evaluated ergonomically with REBA and RULA methods and improvements were made.

With REBA and RULA methods, REBA risk degrees for milling, turning, welding and clamping operations occurring in the maintenance and repair unit are 7 (medium risk), 7 (medium risk), 9 (high risk), 9 (high risk), RULA ergonomic the levels of risk are respectively 4 (low risk), 7 (high risk), 5 (medium risk), 6 (medium risk).

In line with the obtained data, improvement suggestions were made. These improvement suggestions have been determined according to the degree of risk posed by the operator's stance while performing the work. Suggested improvements for turning, clamping, and milling operations that threaten the operator's skeletal and muscular system; repositioning of machine parts so that the operator can operate before or during the operation without shifting to the bending position. It has been proposed to use a mechanical design and a power transmission system to save the operator from the power applied to the machine part for processing it in the machine.

With this study, in addition to the applications handled in the maintenance and repair unit, it is planned to apply REBA and RULA ergonomic evaluation methods in other departments of the factory in the future. In practice in different departments, it is thought that it will be possible to use different evaluation methods in addition to REBA and RULA applications. In addition to the applications planned to be implemented in the future to examine with different methods in case of psychological exposure, apart from the physical load that the operators are exposed to while performing the work.

The definitions of REBA and RULA methods used within the scope of the study and the studies in the literature are included in the introduction part. In the Methodology part, the explanation that the REBA and RULA ergonomics evaluation methods are for the current identified problem is included in this section. In the Case Study part of the study, there are studies conducted with the operators working in the maintenance and repair unit of the REBA and RULA ergonomics evaluation methods in the yarn production line. In the Result and Recommendations part, there is an evaluation of the REBA and RULA methods and suggested improvements. In the Conclusion part, which is the last part of the study, a general evaluation was made.

In the future research additional implications of the investigations and their findings will be discussed (e.g., the case of hybrid work and the postural analysis dynamics [23], occupational health and safety [24]). International collaborations will create the debate between different communities of ergonomists [25] and could extend the methodological framework of the research.

5. REFERENCES

[1] Nurwahidah, M.A., Satria, N.D., *Ergonomic Risk Analysis of Lecture Chairs at The Engineering Faculty, Hasanuddin University*, IOP Conference Series: Materials Science and Engineering, 885(1), 012033, 2020.

[2] Okuyucu, K., Hignett, S., Gyi, D., Doshani, A., *Midwives' Thoughts about Musculoskeletal Disorders with an Evaluation of Working Tasks*, Applied Ergonomics, 90, 103263, 2021.

[3] Santos, J., Sarriegi, J.M., Serrano, N., Torres, J.M., *Using Ergonomic Software in Non-Repetitive Manufacturing Processes: A Case Study*, International Journal of Industrial Ergonomics, 37, 267-275, 2007.

[4] Massaccesi, M., Pagnota, A., Socetti, A., Masali, M., Masiero, C., Greco, F., *Investigation of Work, Related Disorders in Truck Drivers Using RULA Method*, Applied Ergonomics. 34, 303-307, 2003.

[5] Koç, S., Testik, Ö.M., *Mobilya Sektöründe Yaşanan Kas-İskelet Sistemi Risklerinin Farklı Değerlendirme Metotları ile İncelenmesi ve Minimizasyonu*, Endüstri Mühendisliği Dergisi 27 (2), 2-27, 2016 (in Turkish).

[6] Koçak, S.T., Özok, A.F., Kahyaoğlu, N., *Gemi İnşa Sürecinde Ergonomik Değerlendirmeler*, 25 Ulusal Ergonomi Kongresi, Samsun, Türkiye, 2019.

[7] Gómez-Galán, M., Callejón-Ferre, Á. J., Pérez-Alonso, J., Díaz-Pérez, M., Carrillo-Castrillo, J. A., *Musculoskeletal Risks: RULA bibliometric review*, International Journal of Environmental Research and Public Health, 17(12), 4354, 2020.

[8] Dabholkar, T., Dabholkar, Y.G., Yardi, S., Sethi, J., *An Objective Ergonomic Risk Assessment of Surgeons in Real Time While Performing Endoscopic Sinus Surgery*, Indian Journal of Otolaryngology and Head and Neck Surgery, 72:3, 342-349, 2020.

[9] Hignett, S., McAtamney L., *Rapid Entire Body Assessment (REBA)*, Applied Ergonomics. 31:201- 205, 2000.

[10] Tarakçı, E., Can, E., Sakallı, A., Tak, G., *The Ergonomıc Risk Analysis with REBA Method In Production Line*, Ergonomics 3(2), 96 – 107, 2020.

[11] Maldonado-Macías, A., Realyvásquez, A., Hernández, J.L., García-Alcaraz, J., *Ergonomic Assessment for the Task of Repairing Computers in a Manufacturing Company: A Case Study*, Work, 52 (2), 393-405, 2015.

[12] Am-Eam, N., Jankaew, P., Ninthappho, K., Noosom, T., *An Evaluation of Work Posture by REBA: A Case Study in Maintenance Department*, In: Goonetilleke, R., Karwowski, W. (eds) Advances in Physical Ergonomics and Human Factors. Advances in Intelligent Systems and Computing, vol 967. Springer, Cham, 2020.

[13] Nahavandi, D., Hossny, M., *Skeleton-free RULA ergonomic assessment using Kinect sensors*, Intelligent Decision Technologies, 11, 3, 275-284, 2017.

[14] Gajšek, B., Draghici, A., Boatca, M. E., Gaureanu, A., Robescu, D., *Linking the Use of Ergonomics Methods to Workplace Social Sustainability: The Ovako Working Posture Assessment System and Rapid Entire Body Assessment Method*, Sustainability,1 4(7), 4301, 2022.

[15] Choong, S. W. J., Ng, P. K., Yeo, B. C., Draghici, A., Gaureanu, A., Ng, Y. J., ..., Selvan, H. K. T., A *Preliminary Study on Ergonomic Contribution to the Engineering Design Approach of a Wheel Loader Control Lever System*, Sustainability, 14(1), 122, 2021.

[16] Enez, K., Nalbantoğlu, S.S., *Comparison of ergonomic risk assessment outputs from OWAS and REBA in forestry timber harvesting*, International Journal of Industrial Ergonomics, 70, 51-57, 2019.

[17] Kim, M. H., Yoo, W.G., *Effect of a worktable position on head and shoulder posture and shoulder muscles in manual material handling*, Work-a Journal of Prevention Assessment & Rehabilitation, 51 (2), 289-292, 2015.

[18] Takala, E.P., Pehkonen, I., Forsman, M., Hansson, G.A., Mathiassen, S.E., Neumann, W.P., Winkel, J., *Systematic evaluation of observational methods assessing biomechanical exposures at work*, Scandinavian journal of work, environment & health, 36 (1), 3-24, 2010.

[19] Dartt, A., Rosecrance, J., Gerr, F., Chen, P., Anton, D., Merlino, L., *Reliability of assessing upper limb postures among workers performing manufacturing tasks*, Appl. Ergon. 40, 371-378, 2009.

[20] Maslen, B., Straker, L., *A comparison of posture and muscle activity means and variation amongst young children, older children and young adults whilst working with computers*, Work 32, 311-320, 2009.

[21] Bélanger, R., Akre, C., Berchtold, A., Michaud, P.-A., *A U-shaped association between intensity of internet use and adolescent health*, Pediatrics 127, 330-335, 2011.

[22] McAtamney, L., Corlett, N., *RULA: a survey method for the investigation of work-related upper limb disorders*, Appl. Ergon. 24, 91-99, 1993.

[23] Draghici, A., Vaduva, R., Capotescu, S., Banaduc, G., Robescu, D., *Innovations for Tackling Post-Pandemic Related Challenges-A Collaborative Research to Discover New Solutions for Hybrid Work in The Context Of 15-Minute Cities*, Acta Technica Napocensis-Series: Applied Mathematics, Mechanics, and Engineering, 65(1S). 2022.

[24] Dufour, C., Draghci, A., Ivascu, L., Sarfraz, M., *Occupational health and safety division of responsibility: A conceptual model for the*

implementation of the OHSAS 18001: 2007 standard, Human Systems Management, 39(4), 549-563, 2020.

[25] Szabó, G., Balogh, Z., Dovramadjiev, T., Draghici, A., Gajšek, B., Lulić, T. J., ..., Zunjic, A., *Introducing the ergonomics and human factors regional educational CEEPUS Network*, Acta Technica Napocensis-Series: Applied Mathematics, Mechanics, and Engineering, 64(1-S1), 2021.

Evaluarea riscurilor ergonomice a operatorilor dintr-un atelier de reparații și mentenanță a unei fabrici de textile, utilizând metodele REBA și RULA

Rezumat: Articolul prezinta modalitatea de determinare a afecțiunilor sistemului musculo-scheletic ce apar în cazul operatorilor care lucrează în departamentul de mentenanță și reparații al unei companii din industria ușoară. Pentru determinarea scorurilor de risc, aferente sarcinilor de muncă executate de operatori, s-au aplicat metodele REBA și RULA. Ca rezultat al studiului, s-a decis utilizarea compenentelor mecanice pentru reducerea riscurilor, precum și intervenții urgente privind operațiile de prindere, frezare și strunjire. Se intenționează reluarea studiului pentru analiza ergonomică a altor departamente din cadrul companiei.

Dilara MUHACIR, Undergraduate student, Gaziantep University, Department of Industrial Engineering, dilara.muhacir@boyar.com.tr, + 90 342 3172600, Gaziantep, Turkey.

Muhammed İdris AKTAŞ, Ph.D. student, R&D Manager, Boyar Kimya, Department of R&D, idris.aktas@boyar.com.tr, +90 342 3371200, Gaziantep, Turkey.

Eren ÖZCEYLAN, Assoc. Prof., Gaziantep University, Department of Industrial Engineering, erenozceylan@gmail.com, + 90 342 3172600, Gaziantep, Turkey.