

## THE ERGONOMIC RISK ANALYSIS WITH REBA METHOD IN PRODUCTION LINE

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### Keywords

*Ergonomic risk analysis  
REBA  
Assembly work  
Musculoskeletal diseases  
Work-related diseases*

### Abstract

*Ergonomics is a group of multidisciplinary studies that investigate and improve the compatibility of humans with the machine and the environment by examining the physical, environmental and psychological risk factors. The primary purpose of ergonomics is to ensure employee health and safety, and increase work efficiency (such as reduced idle capacity, increased production, increased product quality). Because employing workers in a healthy and safe condition enables an increase in work efficiency. In this study, ergonomic risk analysis was selected on the production line of an enterprise with the REBA method and suggestions for improvement were included. The working cluster consists of 30 unskilled workers on the production line. As a result of the analysis, 66.6% of the production process is at medium risk and 33.4% is at high risk. After the improvement works to be done, it is expected that ergonomic risks would reduce and an increase in production and efficiency.*

## ÜRETİM HATTINDA REBA YÖNTEMİ İLE ERGONOMİK RİSK ANALİZİ

### Anahtar Kelimeler

*Ergonomik risk analizi  
REBA  
Montaj çalışması  
Kas-iskelet hastalıkları  
İşle ilgili hastalıklar*

### Öz

*Ergonomi, fiziksel, çevresel ve psikolojik risk faktörlerini inceleyerek insanların makine ve çevre ile uyumluluğunu araştıran ve geliştiren çok disiplinli çalışma grubudur. Ergonominin temel amacı, çalışanların sağlığını ve güvenliğini sağlamak ve iş verimliliğini arttırmaktır (atıl kapasitede düşüş, üretimde artış, ürün kalitesinde artış gibi). Çünkü; çalışanları sağlıklı ve güvenli bir şekilde çalıştırmak iş verimliliğinde artış sağlar. Bu çalışmada, bir işletmenin seçilen üretim hattında REBA yöntemi ile ergonomik risk analizi yapılmıştır ve iyileştirme önerileri sunulmuştur. Çalışma kümesini üretim hattında çalışan 30 düz işçi oluşturmaktadır. Yapılan REBA analizi sonucunda, üretim sürecinin %66,6'sı orta riskte ve %33,4'ü yüksek risk altında olduğu gözlenmiştir. Yapılacak iyileştirme çalışmaları sonucunda ergonomik risklerin azalacağı, üretim ve verimlilikte artış olması beklenmektedir.*

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## 1. Introduction

With the development of technology, although automation systems have been used instead of a human in industry, human labor is still indispensable in many production systems. When ergonomic risk factors are examined in these systems where manpower is needed, working positions, especially physical risk factors, are of great importance. One of the production processes that need manpower is assembly processes. In some work done in assembly processes in organizations, postures that disturb employees emerge. The employees in the assembly process work by leaning, rotating, standing or lying down. These studies employee health and performance affect and are ergonomically unsuitable ways of working.

Improper postures are defined as the deviation of one or more limbs from the stationary body posture. Incorrect working postures of employees can cause pain and discomfort and fatigue in some body areas, especially in the back, waist and neck. For this reason, these postures not only cause musculoskeletal disorders but also decrease the work performance and production quality of the employee. Examining and evaluating the working postures, which is an important issue for both the organization and the employee, has an important place in the science of ergonomics (Akay et al., 2003).

According to a manual worker, the height of a work surface is an essential determinant of the upper limb (arms) effort and the potential for injury to the musculoskeletal system. The industrial ergonomic design suggests a working height of about 5 cm below the elbow height and is an acceptable range 12.5 cm below, 2.5 cm above the elbow height (Berquer et al., 2002).

Two-thirds of workers in Europe state that they perform repetitive movements of the hand or arm for at least a quarter of their working time. This kind of repetitive motion exposure is associated with the risk of developing musculoskeletal disorders in the upper extremities (Claudon et al., 2020).

Work-related musculoskeletal disorders are a problem for many countries in the world. In the UK, the Health and Safety Executive (HSE) stated that upper extremity (arms) disorders are not only seen in a particular business line but are common in jobs requiring the labor force. However, HSE reports that work-related musculoskeletal disorders are the most common occupational diseases affecting 1 million employees a year, with problems such as low back pain, joint injuries and recurrent strain

injuries. In a country-wide study in Taiwan, 37.0% of 18,942 people reported that they had work-related musculoskeletal disorders. In the United States, Bureau of Labor Statistics said that 552,528 people had work-related musculoskeletal diseases and a total of 329,920 employees were unemployed in the service sector in the annual survey of occupational injuries and illnesses in 2001 (Fang et al., 2007).

Martin et al. (2009), they analyzed the situations surrounding workplace tasks performed using auxiliary equipment (ladders, scaffolding, etc.) and that could cause falls. They identified the causes that had the most significant impact on accidents involving ancillary equipment. These reasons include the adoption of wrong postures during work and the insufficient knowledge of a worker, covering most of the safety regulations. Similarly, the duration of the tasks has been associated with these variables and thus, the accident rate.

Musculoskeletal system diseases constitute a significant part of diseases experienced by most organizations. From back strain to carpal tunnel syndrome, in an organization, musculoskeletal system diseases can find 40% or more of injury cases and 60% of compensation costs. Safety experts, engineers and human resources managers have turned to the science of ergonomics to understand and address working conditions that increase the risk of musculoskeletal diseases. Production managers also resort to the science of ergonomics for applications that increase efficiency and efficiency. The musculoskeletal system often requires a two-way ergonomics application to prevent disease and increase efficiency: a reactive program for identifying, analyzing and correcting "problematic jobs", a proactive process that harmonizes ergonomics with the process and product design (Adams, 2005).

Another health problem highlighted in research in recent years is musculoskeletal disorders or physical symptoms. These are muscle, nervous, or joint disorders that can occur anywhere on the body, although they most commonly affect the neck, back, and upper extremities. Working conditions are directly related to musculoskeletal disorders, although these disorders can result from factors outside the workplace and even have personal causes. Prevention of musculoskeletal disorders is directly related to the correct design of the work (for example, allocated space or providing adequate lighting) and physical demands (for example, transporting heavy loads and performing repetitive tasks) (García-Herrero et al., 2012).

In addition to being a problem of musculoskeletal system disorders for workers' health, these disorders create a significant financial burden on society. Most of the financial losses associated with occupational accidents and occupational diseases include musculoskeletal disorders (Takala, 2002), and these musculoskeletal disorders are the main cause of time-loss injuries in developed countries (Brage et al., 1998; Woolf & Pfleger, 2003).

García-Herrero et al., (2012), reports that when looking at studies on occupational health and safety aimed at preventing injury, there are enough studies focused on physical aspects, ergonomic factors and musculoskeletal disorders (De Jong et al., 2003; Ghahramani, 2000; Ghosh et al., 2010; Hess et al., 2004) Also, hygienic conditions such as temperature and noise are focused (Anttonen et al., 2009; Ashraf et al., 2005; Morabito et al., 2006).

There are many studies in the literature such as; ergonomic conditions (Hoyos, 1995; Makhbul et al., 2008), ergonomic working conditions, job satisfaction (Kaya et al., 2011) focused on the impact of monotonous work and repetitive tasks (Melamed et al., 1995) on stress.

It has also been found that stress leads to increased absenteeism rate, accidents, injuries and diseases. Stress does not only affect the health of the individual, but it also disrupts the functioning of the organization (Sakalli, 2019).

Ergonomics improves employee productivity, protects the health and ensures safety. Besides, ergonomic working conditions increase job satisfaction. This situation directly or indirectly affects the productivity of the employee (Kaya et al., 2011).

Human factor engineering (Ergonomics) researches information about human behavior, abilities, limitations and other characteristics to design tools, equipment, machinery, systems, work, work-flow and order, and environmental factors to provide efficient, safe, comfortable and effective use and applies (Güler, 1997: 9).

Ergonomics acknowledges that any system always produces two results: performance and well-being. The focus of ergonomics on two common results is a feature that distinguishes it from other disciplines. Other disciplines such as engineering, psychology, and medicine focus on one of the results with ergonomics, but not both results (Dul et al., 2012).

According to García-Herrero et al.'s study in 2012, optimizing these conditions related to

hygiene and ergonomics in the workplace can reduce the occupational accident rate up to four times the initial value according to the sensitivity analysis performed.

Another factor that makes working stance important is the decrease in the level of quality. According to the study done by Axelsson in 1995, the poor quality of the work in the wrong posture stated that it was 10 times more than doing the same job in the right posture. Because there is a significant difference between a job that the employee will do without being forced and the quality level of the job when they are forced (Axelsson, 1995).

In this study; The postures during the work, especially the working ailments caused by improper working postures on the production lines, and workforce losses were examined. Ergonomic risk analysis was performed with the REBA (Rapid Entire Body Assessment) method by observing the 6 stages of workstations/production line determined to improve the improper working postures.

Related improvement suggestions are presented according to the risk scores obtained. As a result of improvement studies, it is aimed to protect employee health and increase work efficiency by reducing the disturbances in the musculoskeletal system.

## **2. Application Place and Method**

### **2.1. Application Place**

This study was carried out in a facility that produces water and gas valves of various diameters. Products are intended to use for residential and industrial. Valves produced in the heavy metal industry environment consist of four main parts: trunk, ball, gasket and open/close boom.

In this study, it was aimed to determine the ergonomically inappropriate working postures and movements by observing the stages of the valve production process. Ergonomic risk analysis was carried out with the REBA (Rapid Entire Body Assessment) method by observing and recording 6 stages of production line employees to determine and improve the inappropriate working postures at the diecasting industry factory. There are 30 employees in the 6 stages of the production line. All of them have a minimum of 5 years of experience and they are unskilled workers. The study cluster was chosen randomly.

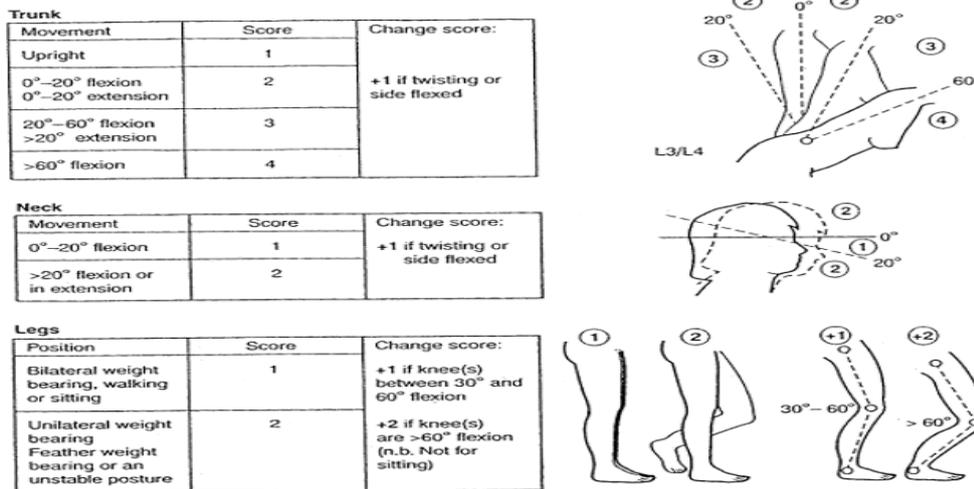
Failure ergonomic postures and movements have been detected and analyzed.

**2.2. Method (REBA- Rapid Entire Body Assessment)**

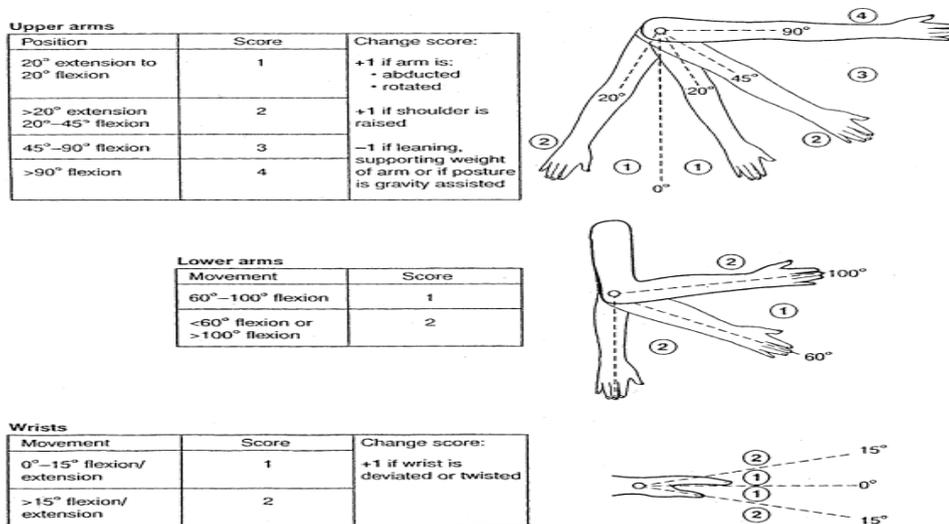
The REBA (Rapid Entire Body Assessment) method is an observational method developed to analyze all parts of the body and to identify risks in body positions (Hignett and McAtamney,

2000). This method enables the detection and prevention of inappropriate working postures that may cause work-related muscle and skeletal disorders.

When calculating the REBA score, body parts; It is divided into two groups as Group A (Body, Neck, Legs) as seen in [Figure 1](#) and Group B (Upper Arms, Lower Arms, Ankles) as seen in [Figure 2](#).



**Figure 1. Group A Body Part Diagram and Scores**



**Figure 2. Group B Body Part Diagram and Scores**

A score consisting of a combination of these scores is determined with the help of [Table 1](#) by determining the scores of the trunk, neck and legs separately.

A Score is obtained by adding the Load / Force score to this score.

**Table 1. Table A and Load**

Table A													
Trunk		Neck											
		1				2♦				3			
1 2 3 4 5♦	Legs	1	2	3	4	1	2	3	4	1	2	3	4
		1	2	3	4	1	2	3	4	3	3	5	6
		2	3	4	5	3	4	5	6	4	5	6	7
		2	4	5	6	4	5	6	7	5	6	7	8
		3	5	6	7	5	6	7	8	6	7	8	9
	4	6	7	8	6	7	8	9	7	8	9	9	

Load/Force			
①	1	2	+1
< 5 kg	5-10 kg	> 10 kg	Shock or rapid build up of force

B score consisting of a combination of these scores is determined with the help of Table 2 by determining the scores of upper arm, lower arm and wrists separately.

B Score is obtained by adding a Coupling score to this score.

**Table 2. Table B and Coupling**

Table B							
Upper arm		Lower arm					
		1			2♦		
	Wrist	1	2	3	1♦	2	3
1		1	2	2	1	2	3
2		1	2	3	2	3	4
3♦		3	4	5	4	5	5
4		4	5	5	5	6	7
5		6	7	8	7	8	8
6		7	8	8	8	9	9

Coupling			
0 Good	① Fair	2 Poor	3 Unacceptable
Well-fitting handle and a mid-range, power grip	Hand hold acceptable but not ideal or coupling is acceptable via another part of the body	Hand hold not acceptable although possible	Awkward, unsafe grip, no handles  Coupling is unacceptable using other parts of the body

Then, using Table 3, C Score, which is a combination of A and B scores, is obtained.

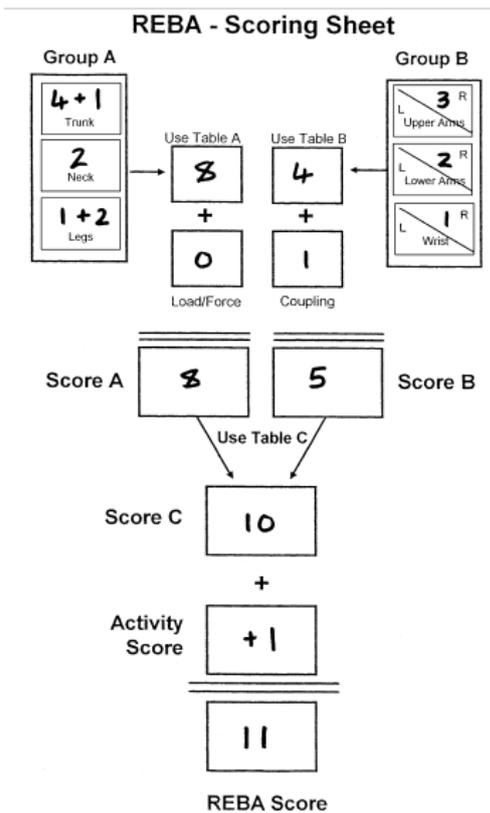
REBA Score is obtained by adding the Activity score to the C Score.

**Table 3. Table C and Activity Score**

		Table C											
		Score B											
S c o r e		1	2	3	4	5	6	7	8	9	10	11	12
	1	1	1	1	2	3	3	4	5	6	7	7	7
	2	1	2	2	3	4	4	5	6	6	7	7	8
	3	2	3	3	3	4	5	6	7	7	8	8	8
	4	3	4	4	4	5	6	7	8	8	9	9	9
	5	4	4	4	5	6	7	8	8	9	9	9	9
	6	6	6	6	7	8	8	9	9	10	10	10	10
	7	7	7	7	8	9	9	9	10	10	11	11	11
	8	8	8	8	9	10	10	10	10	10	11	11	11
	9	9	9	9	10	10	10	11	11	11	12	12	12
	10	10	10	10	11	11	11	11	12	12	12	12	12
	11	11	11	11	11	12	12	12	12	12	12	12	12
	12	12	12	12	12	12	12	12	12	12	12	12	12

Activity score

- +1 • 1 or more body parts are static, e.g. held for longer than 1 min
- +1 • Repeated small range actions, e.g. repeated more than 4 times per minute (not including walking)
- (+1) • Action causes rapid large range changes in postures or an unstable base



**Figure 3. REBA Score Sheet**

REBA action levels

Action level	REBA score	Risk level	Action (including further assessment)
0	1	Negligible	None necessary
1	2-3	Low	May be necessary
2	4-7	Medium	Necessary
3	8-10	High	Necessary soon
(4)	11-15	Very high	Necessary NOW

**Table 4. REBA Action Levels**

The REBA (Rapid Entire Body Assessment) method is an observational method developed to analyze all parts of the body and to identify risks in body positions in [Figure 3, Table 4](#).

Action is taken improvement activity according to the degree of risk detected.

**3. Results of Application**

In this study, it was aimed to determine the ergonomically inappropriate working postures and movements by observing the stages of the valve production process. Failure ergonomic postures and movements have been detected and analyzed.

As a result of the analysis, as seen in [Table 5](#), 66.6% of the production process is at medium risk and 33.4% is at high risk. After the improvement works to be done, it is expected to

increase employee satisfaction and performance, production efficiency, quality and production speed on the other hand decrease work-related diseases that may occur in the employee.

### 3.1. Cutting the Brass Rod Bale with Shears

The employee has to stoop the waist and neck forward and apply a strong force to the shears to cut the bale tie. As seen in [Figure 4](#), the REBA score is 6 and the risk level is medium.

Improvement activity is necessary.

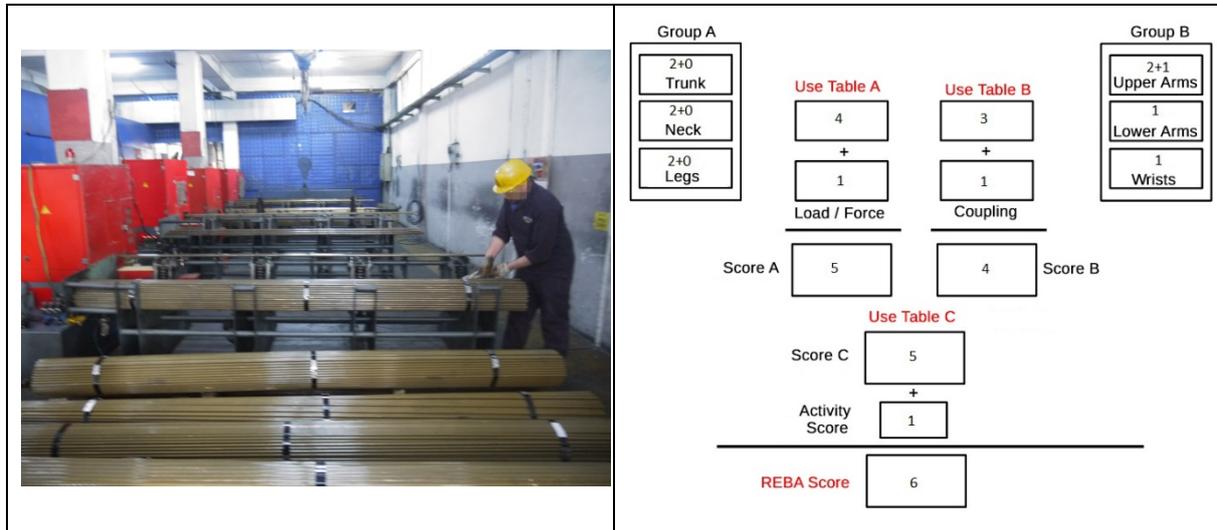


Figure 4. Cutting the Brass Rod Bale with Shears and REBA Score

### 3.2. Loading the Raw Valves on The Deburring Machine

Sliced bar pieces from the sawing machine are pressed in the press machine and after being shaped as a valve, they are loaded to the deburring machine by a worker using a shovel. As

seen in [Figure 5](#), when the REBA analysis performed in this stage, the REBA score is 10, and the risk level is high.

Improvement activity is necessary as soon as possible.

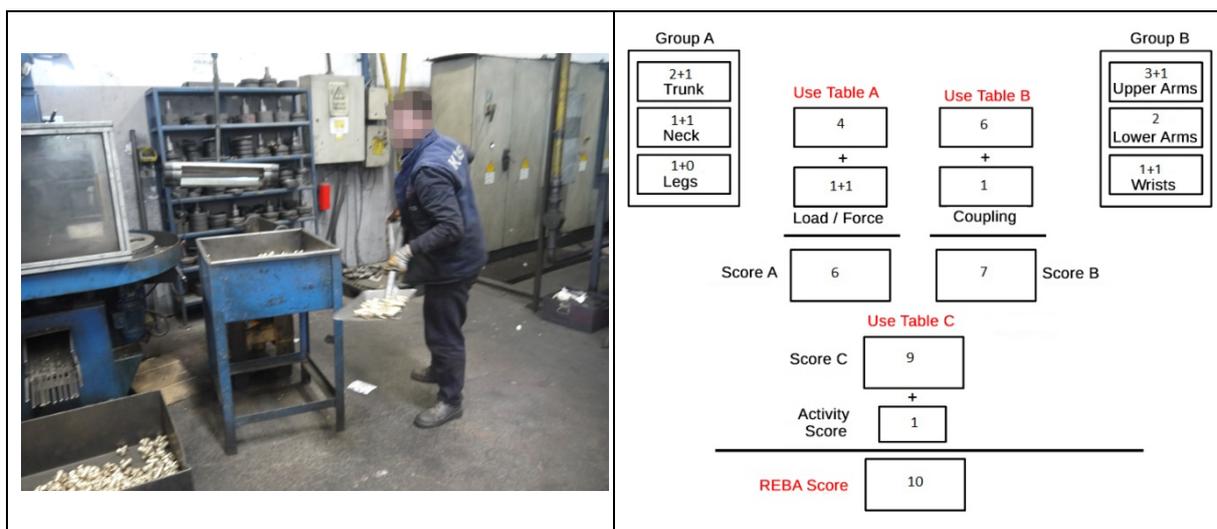


Figure 5. Loading the Raw Valves on The Deburring Machine and REBA Score

### 3.3. Processing of The Thread Parts of The Valves on CNC

Deburring valves are placed manually by an employee in the CNC machine to thread their

mouth. In the REBA analysis performed in this stage, the REBA score is 6 and the risk level is medium (Figure 6).

Improvement activity is necessary.

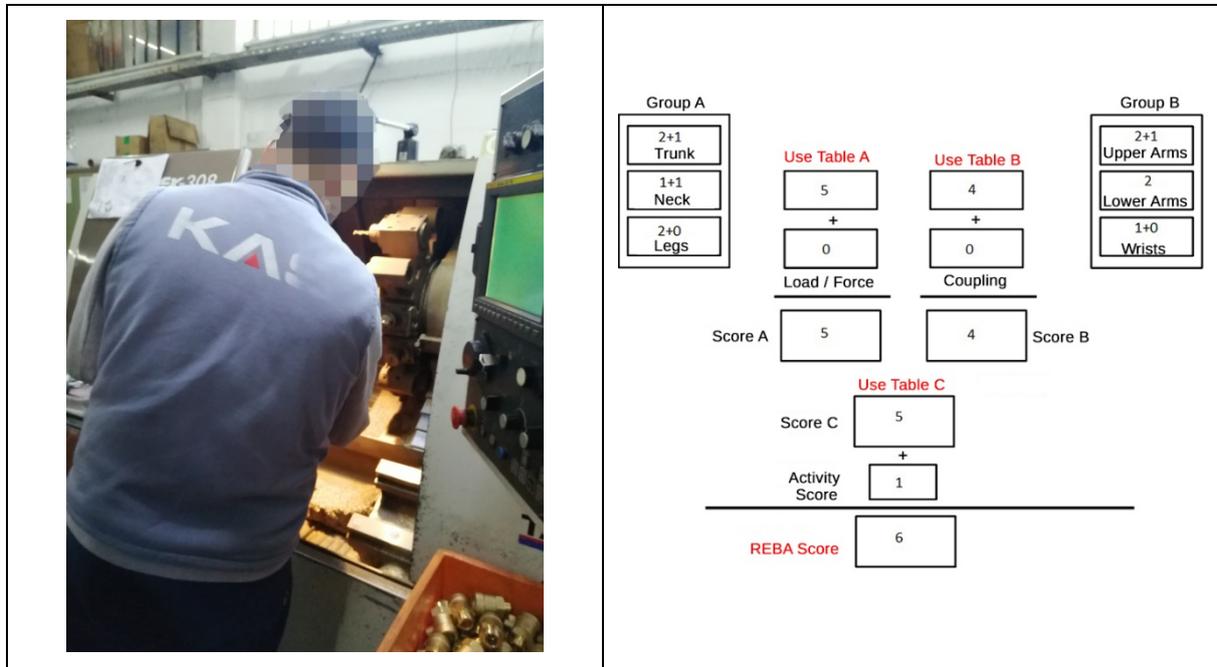


Figure 6. Processing of The Thread Parts of The Valves on CNC and REBA Score

### 3.4. Realization of Chrome Plating Process

The valves are immersed in the plating bath to realize chrome plating. This process is carried out in the same way in three different bathrooms in a

row. The employee always has to stoop. In the REBA analysis performed in Figure 7, the REBA score is 8 and the risk level is high. Improvement activity is necessary shortly.

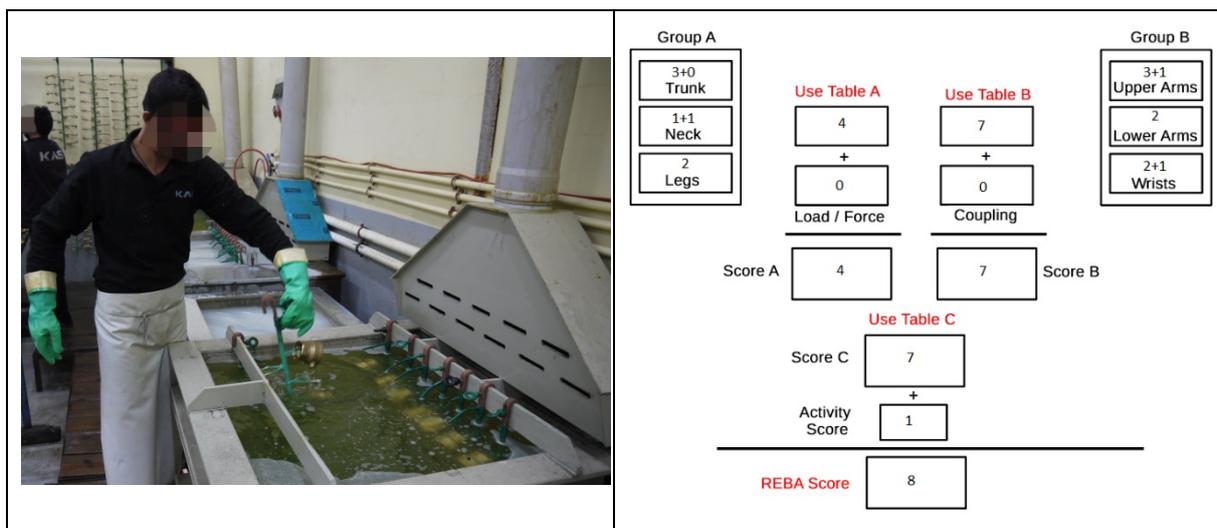


Figure 7. Realization of Chrome Plating and REBA Score

### 3.5. Assembly of Valve Parts

Valve parts are automatically mounted to each other by manually placing the molds on the drum in a machine. The employee takes the 3 main parts (trunk, gasket, cap) with his hand from the

material case on the side and places them in the mold. In the REBA analysis performed in this stage, the REBA score is 5 and the risk level is medium. Improvement activity is necessary (Figure 8). Improvement activity is necessary.

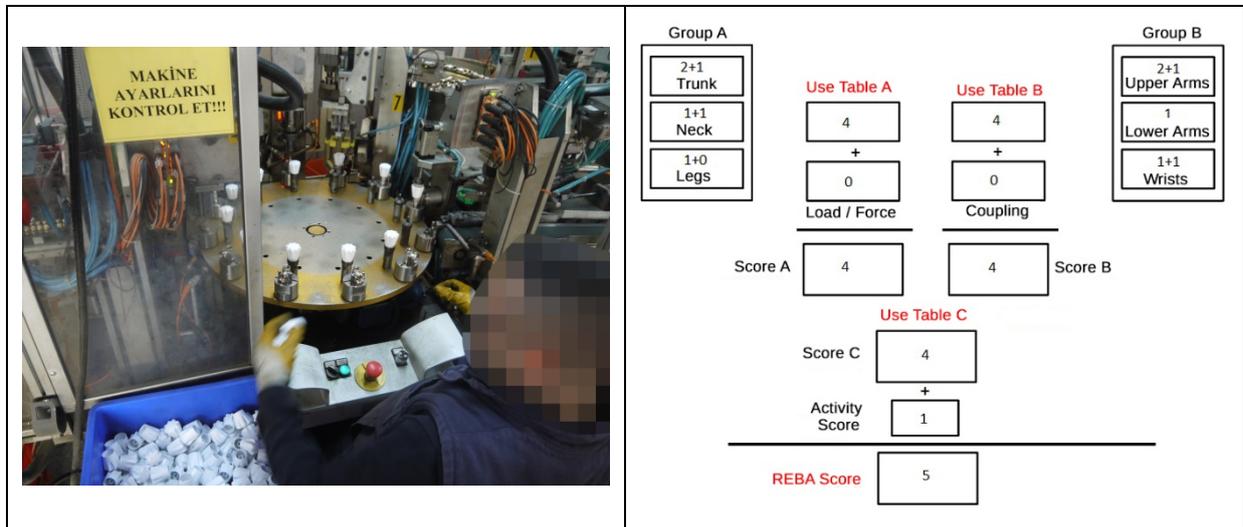


Figure 8. Assembly of Valve Parts and REBA Score

### 3.6. Placing in The Packaging Machine

The assembled valves are placed in the packaging machine manually by the employees. As a result

of the calculation, as seen in Figure 9, the REBA score is 5 and the risk level is medium. Improvement activity is necessary.

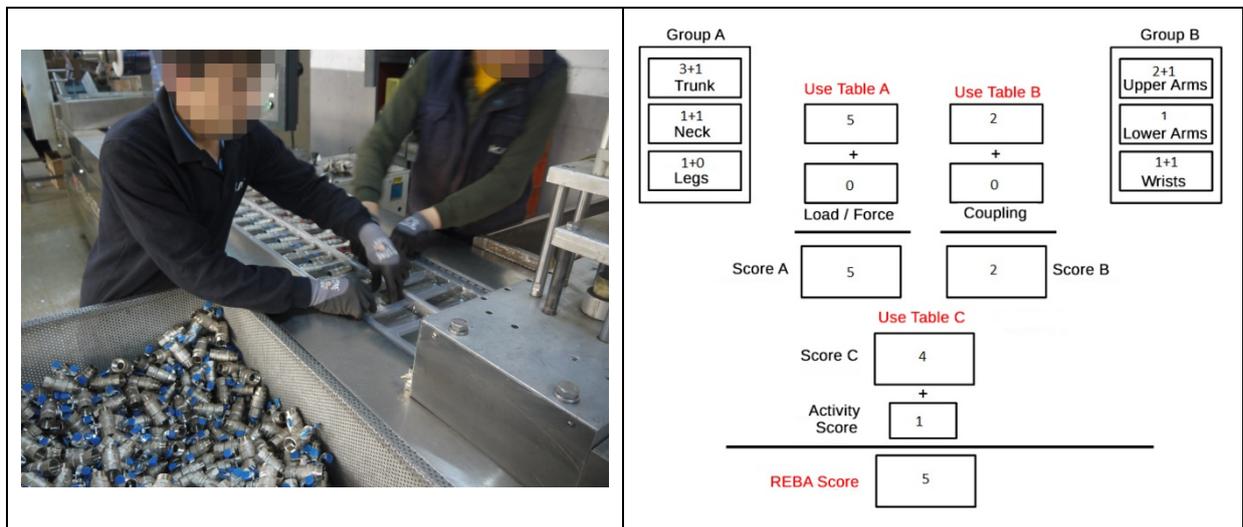


Figure 9. Placing in The Packaging Machine and REBA Score

### 4. Conclusion

In conclusion, ergonomically inappropriate working postures and movements were

determined with the REBA method by observing 6 stages of the production line.

As a result of the analysis, as seen in Table 5, 66.6% of the production process is at medium risk and 33.4% is at high risk.

**Table 5. REBA Scores and Risk Levels before&after Improvement Suggestions**

Process of Production Line	First Reba Score	First Risk Level	Action	Improvement Suggestions	Last Reba Score	Last Risk Level
Cutting the brass rod bale with shears	6	Medium	Necessary	Using electronic iron cutting shears	1	Negligible
				Raising the bar feeding platform		
Loading the raw valves on the deburring machine	10	High	Necessary Soon	Using mobile load platform	1	Negligible
				Establishing a conveyor transfer system		
Processing of the thread parts of the valves on CNC	6	Medium	Necessary	Placing the material boxes to be processed at an adjustable angle and distance	2	Low
Realization of chrome plating	8	High	Necessary Soon	Raising the hanger length	3	Low
Assembly of valve parts	5	Medium	Necessary	Placing semi-finished material boxes at an adjustable angle and distance	2	Low
Placing in the packaging machine	5	Medium	Necessary	Placing the product material boxes at an adjustable angle and distance	2	Low

A significant decrease in risk levels is expected after improvement suggestions in [Table 5](#).

In consequence of improvements in the design and providing rotation between the stations among the employees; It is expected to increase employee satisfaction and performance, production efficiency, quality and production speed on the other hand decrease work-related diseases that may occur in the employee.

Khan et al., (2018) in his work, they determined that the shoulder was the most affected body area and then the neck, by combining REBA and NMQ in the ergonomic analysis of 51 railway workers.

In a study, the prevalence of musculoskeletal disorders for different body parts was 75.9% for the neck, 58.6% for the shoulders, 56.9% for the upper back, 48.3% for the waist and 44.8% for the wrist. Job analysis using REBA showed that 89.6% of limbs in group A and 79.3% of limbs in group B had a score. Only neck and low back pain

have a significant relationship with the risk levels obtained using the REBA method (Rafeemanesh et al., 2013).

Similar findings were obtained according to the results of REBA analysis in the literature. Neck, trunk and upper arm are the most affected body area.

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### Conflict of Interest

No conflict of interest was declared by the authors.

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