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Ergonomic Risk Analysis of Working Postures for a Textile Factory Worker

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Abstract − The textile sector significantly contributes to total employment and exports in our country. At the same time, it has a production structure that is labor-intensive and where most of the work is done manually and repetitively. As a result of shift work and long working hours in textile production, some musculoskeletal disorders occur in employees due to non-ergonomic posture and repetitive movements. Untreated and neglected musculoskeletal disorders cause more serious problems for employees in the long term. In this study, ergonomic risk assessment was conducted using the Rapid Entire Body Assessment Method for the working postures of textile workers working in the weaving department of a textile factory. Thus, potential risk factors and ergonomic strain levels exposed to employees were determined. As a result of the research, it was determined that the employee was exposed to high risk, and precautions needed to be taken quickly. In addition, some recommendations were made to prevent musculoskeletal disorders and loss of productivity in the business through some precautions.

Keywords − *Rapid entire body assessment (REBA) method, ergonomics, musculoskeletal disorders, textile*

1. Introduction

Ergonomics is the harmonization of working and living conditions with humans, and ergonomics aims to prevent occupational diseases and work accidents and improve working conditions to protect and develop employees mentally and physically. In the workplace, frequent repetitive movements, use of non-ergonomic equipment, straining and incorrect working postures, long working hours, inadequate rest periods, excessive strain, and heavy lifting cause some discomfort in employees. The most important of these disorders is musculoskeletal system diseases. Musculoskeletal disorders affect the musculoskeletal system, including muscles, tendons, ligaments, joints, and nerves. It can be seen in certain body parts such as the back, neck, shoulders, arms, wrists, hands, and legs. Symptoms usually present as pain, discomfort, stiffness, weakness, numbness, tingling, or limited range of motion. Work-related musculoskeletal disorders (MSDs) are related to occupational activities and conditions. They are caused by factors such as repetitive movements, forceful efforts, awkward postures, vibration, heavy lifting, positions involving prolonged static loads, or exposure to ergonomic hazards [1]. According to the World Health Organization (WHO), MSDs account for approximately 40% of all occupational diseases. In addition, if no precautions are taken after a worker contracts MSD, the new worker working at that job may also contract the same disease; thus, WHO accepts MSDs in the epidemic disease category [2].

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Having MSDs causes some negative consequences not only for employees but also for businesses. Some negative consequences are reduced productivity, work planning and process disruptions due to employee absenteeism, and sickness costs. These illnesses significantly affect employees' ability to perform their duties effectively and efficiently. Depending on the severity of the condition, employees may experience functional limitations, reduced productivity, increased absenteeism, and even disability [3].

There are various systematic approaches to identifying and assessing ergonomic risks and hazards. One of these is the Rapid Entire Body Assessment (REBA) method. This method is applied by evaluating the applied force, repetitive movements, and duration of postures through observation. The REBA method is a biomechanical tool commonly used to assess work-related MSDs. It is recognized as an effective method for identifying ergonomic risks in the workplace and implementing preventive measures.

The textile industry is an important sector worldwide and employs millions of people. It is one of the sectors with a large contribution share to total employment and exports in Turkey. At the same time, it has a production structure that is labor-intensive and where most of the work is done manually and repetitively. Some musculoskeletal diseases may occur in textile production workers who work shifts and long hours due to non-ergonomic posture and repetitive and inappropriate movements.

Some of the studies in the literature on ergonomic risk factors that threaten employees in the work environment, ergonomic risk analyses, and musculoskeletal disorders seen in employees are summarized below: Viera and Kumar [4] contributed to the scientific literature by examining working postures and conducting research on workers in different occupations to determine what kind of ergonomic difficulties working postures cause. Saraji et al. [5] used the REBA method to evaluate the ergonomic conditions in dentistry professions and the relationship between MSD and working conditions in different body parts. The Scandinavian Musculoskeletal Questionnaire (NMQ) for the prevalence of MSD concluded that professional training given to dentists for correct working conditions and postures should be increased. Using the REBA method, Mahdavi et al. [6] investigated musculoskeletal disorders in 172 female hairdressers at risk of MSD in Khorramabad, Iran. As a result, they concluded that standing for long periods, inappropriate working positions, trunk flexion, high effort, and repetitive movements are risk factors for musculoskeletal disorders. Atıcı et al. [7] conducted a REBA analysis in their study to improve improper working practices in a cable manufacturing company in the automotive industry. As a result of their analysis, they observed that workers were experiencing difficulties. They offered improvements to minimize the difficulties. Madani and Dababneh [8] evaluated the observation-based REBA, an ergonomic assessment tool, in terms of its development, applications, validity, and limitations and showed that REBA is suitable for evaluating jobs in a wide range of professional environments in terms of posture as a result of research. Çoker and Selim [9] examined the working positions of workers in a textile company in the cutting room, sewing room, model, and fabric warehouse departments. They conducted an ergonomic risk analysis using the REBA method. As a result of the study, they made recommendations to the company management regarding the working conditions to increase the health and safety of employees, work efficiency, and quality. Haekal et al. [10] used the REBA method in a pharmaceutical company to analyze the operator's posture while working in a packaging material warehouse. They provided suggestions to improve the activities that caused complaints. Kırcı et al. [11] investigated the ergonomic risk assessment of a logistics warehouse. The working postures of the workers were examined using REBA, rapid upper limb assessment (RULA), and National Institute for Occupational Safety and Health (NIOSH) methods. In addition, the ambient noise, personal noise, ambient dust, personal dust, vibration, chemical and thermal comfort values were measured with accredited devices. Özay and Özcan [12] analyzed five different cleaning jobs and twelve working posture positions in two different workplaces using the REBA method. For this purpose, both companies were visited once a week, four times a month, and postures were recorded, monitored, and photographed. As a result of these analyses, it was stated that four of the working positions were calculated as moderately risky, and one had a low-risk score. Tarakçı et al. [13] conducted an ergonomic risk analysis using the REBA method on a selected production line of a company and presented suggestions for improvement. As a result of the REBA analysis, it is stated that 66.6% of the production process is at medium risk, and 33.4% is at high risk. Akalp et al. [14] examined the postures of 20 agricultural workers in olive cultivation in the

Marmara Region using the REBA method and suggested solutions to reduce risk levels. Şahin and Vapur [15] conducted ergonomic risk analyses in a women's hair salon. REBA and RULA methods were used. 8 basic procedures performed in the hair salon were evaluated; 2 procedures were identified as high risk and 6 procedures as medium risk. Muhacır et al. [16] aim to evaluate the ergonomic risks of operators in the maintenance and repair workshop of a textile factory with REBA and RULA methods. As a result, it is stated that reducing ergonomic risks is critical to increasing workers' health and productivity. Kee [17] aims to systematically compare three methods related to MSDs: Ovako Work Posture Analysis System (OWAS), RULA, and REBA. The study noted that RULA was the most used method among the three techniques; many studies adopted RULA even in assessing unstable lower limb postures. Amri and Putra [18] aimed to reduce the risk level gained by conducting Rapid Office Strain Assessment (ROSA) and REBA for office workers in engineering departments. Posture analysis data processing using the ROSA method indicated that five employees surveyed were at risk levels and required immediate correction. The REBA method indicated that five employees were at risk of urgent needs and requirements. In their study, Varghese et al. [19] applied the REBA method for posture analysis of rubber tappers. It was found that most of the workers (84%) were at moderate risk of MSDs, while the remaining 16% of the participants were at high risk and required immediate corrective measures. Kavus et al. [20] compared the REBA methodology developed using artificial neural networks and neuro-fuzzy systems in the ergonomic risk assessment of service workers. The study examined the differences and advantages between these two methods and evaluated the effectiveness of each in determining ergonomic risks. As a result, it was found that artificial neural networks provide higher accuracy rates, while neuro-fuzzy systems stand out with their flexibility and interpretability. Arslan and Ünver [21] analyzed three work postures of workers in the hot rolling section of an iron and steel factory in Karabük using the REBA method. They made recommendations to reduce risk levels according to the REBA results.

Ayvaz et al. [22] evaluated the ergonomic risks of working positions of nurses working in a medical faculty hospital using REBA and RULA methods. 383 nurses were examined in the study, and moderate ergonomic risks were detected, especially in departments such as operating rooms. The majority of nurses experienced musculoskeletal disorders. As a result, it was emphasized that working positions should be improved. Kibria [23] examines the ergonomic analysis of working positions at a construction site with REBA and RULA methods. The research aims to evaluate the ergonomic risks workers encounter at the construction site during work and provide the necessary recommendations to reduce these risks and increase occupational safety. The results show that most workers work at medium and high-risk levels and that ergonomic improvements are needed. Kodle et al. [24] conducted a study to identify musculoskeletal disorders among workers in the mining industry. The study administered a questionnaire to twenty-five operators, followed by workplace observations.

The results indicated that more than 90% of the employees were exposed to high-risk levels, and immediate changes were necessary. Yunian et al. [25] analyzed the welding operators' body positions and working conditions using the REBA method in their study. The research revealed that most welding operators are at high ergonomic risk, negatively affecting work efficiency. It has been stated that incorrect body positions and inappropriate working conditions reduce the performance of workers by causing musculoskeletal problems. Biradar et al. [26] aimed to determine ergonomic risks associated with job duties within the company by performing posture analysis in their study. In the study, an evaluation was made, and recommendations were developed to reduce these risks. Gür et al. [27] analyzed the postures of emergency service workers during patient intervention using the REBA and RULA methods. These analyses aimed to take precautions in advance for risky postures that may cause occupational musculoskeletal diseases. At the end of the study, it was stated that two posture positions were in the low-risk category, one in the medium risk category, one in the very high-risk category, and three in the high-risk category.

When the literature is investigated, it is seen that ergonomic analyses conducted within the textile sector are generally made by evaluating employees in the ready-made clothing and apparel departments. However, the sector has a labor-intensive production structure, and since there is a lot of manual work in most production and departments, examining other units is of great importance in terms of precautions to be taken. In textile factories, manual work, such as carrying, lifting, etc., is common in the weaving departments. This study aims to analyze the working postures and ergonomic strains of a textile worker in the weaving department of a textile factory using the REBA method, one of the ergonomic risk assessment techniques. At the end of the study, potential risk factors and ergonomic strain levels to which workers are exposed were determined. Some precautions can be taken when acceptable limit values are exceeded and are specified, and suggestions are made.

2. Materials and Methods

This study examined the movements of textile workers working in the weaving department of a textile factory in Tekirdağ. In the weaving department, workers wrap the fabric on the roll, cut it, and carry it. These processes are carried out manually. In order to perform ergonomic risk analysis using the REBA method, the company was visited and the workers' movements in the relevant department were carefully observed and recorded with video and photography. The REBA method is developed by Hignett and McAtamney [28], especially useful for identifying risks in manual handling, lifting, etc. The REBA method aims to create a posture analysis system sensitive to musculoskeletal risks in various tasks. This system aims to provide a scoring system for muscle activity resulting from static, dynamic, rapidly changing, or unstable postures by dividing the body into segments to be coded individually. In addition, the method offers an action level that indicates urgency [28]. In the REBA method, dynamic and static postures can be analyzed, allowing the entire body to be evaluated.

REBA evaluates body posture factors by assigning points to each area for each critical job task. In this way, the risk caused by a working posture or movement to be analyzed is expressed numerically. When using REBA, the right and left sides of the body are evaluated simultaneously. In the REBA method, a score ranging from 1 to 15 depends on the stretching and bending in the trunk, neck, legs, upper arms, lower arms, and wrists during a working posture and the loads the worker is exposed to during these postures. To determine the REBA score, the body is first examined in two parts, group A and group B. Table 1 includes Group A components, and the trunk, neck, and legs are examined according to this table.

Table 1. Group A body diagrams [28]

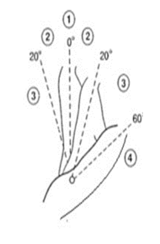
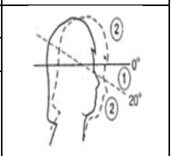
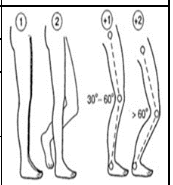
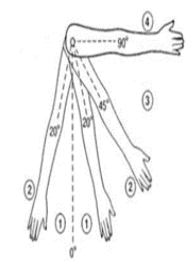
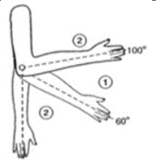
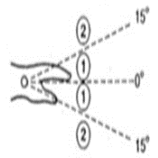
TRUNK			
Movement	Score	Change Score	
Upright	1	If there is a twisting or side flexed, add +1 to the score.	
0˚-20˚ Flexion 0˚-20˚ Extension	2		
20˚-60˚ Flexion >20˚ Extension	3		
>60˚ Flexion	4		
NECK			
Movement	Score	Change Score	
0˚-20˚ Flexion	1	If there is a twisting or side flexed, add +1 to the score.	
>20˚ Flexion or Extension	2		
LEGS			
Movement	Score	Change Score	
Bilateral weight bearing, walking or sitting	1	If there is flexion between 30˚-60˚ in the knees, add +1 to the score	
Unilateral weight bearing. Feather weight bearing or an unstable posture	2	If >60˚ flexion, add +2 to score (in standing position)	

Table 2 includes the components of Group B, and in Group B, the upper arm, lower arm, and wrists are examined.

Table 2. Group B body diagrams [28]

UPPER ARMS			
Movement	Score	Change Score	
Extension and Flexion up to 20˚	1	If the arm is rotated or extended, add +1 to the score. If the shoulder is raised, add +1 If the movement is done with gravity support, it will be -1.	
>20˚ Extension 20˚-45˚ Flexion	2		
45˚-90˚ Flexion	3		
>90˚ Flexion	4		
LOWER ARMS			
Movement	Score	Change Score	
60˚-100˚ Flexion	1	If there is rotation or stretching, add +1 to the score	
<60˚ Flexion and >100˚ Flexion or Extension	2		
WRISTS			
Movement	Score	Change Score	
0˚-15˚ Flexion or Extension	1	If the wrist is twisted or deviated, add +1 to the score.	
>15˚ Flexion or Extension	2		

In group A, the trunk, neck, and legs are examined; in group B, the upper arms, lower arms, and wrists are examined. After the individual scores for the trunk, neck, and legs are determined, a score is determined by combining these scores. The A score is obtained by adding the carried load/force score to this score. Table 3 shows the Load/Force Score table.

Table 3. Load/Force score table [28]

0	1	2 ♦	+1
<5 kg	5-10 kg	>10 kg	When sudden or rapidly increasing use of power is required

Similarly, separate scores are determined for the upper arm, lower arm, and wrist, and a score is determined by combining these scores. The coupling score is added to this score to obtain the B score. Table 4 shows the coupling table.

Table 4. Coupling table [28]

0 Good	1 Fair ♦	2 Poor	+1 Unacceptable
Well-fitting and moderate forceful coupling with the hand	Hand is acceptable but not ideal, or coupling is acceptable via another part of the body	Hand-holding is possible but not acceptable	Improper or unsafe grip; no grip or grip not suitable for another body part

Finally, the C score, which consists of A and B scores, is obtained, and the REBA score is obtained by adding the activity score to this score [29]. According to the REBA rating table, where action levels are determined, the REBA rating can be between 0-4, the REBA score can be between 1-15, and the measures to be taken differ according to the determined score [28].

3. Results and Discussion

In the study, the working postures of a worker in the weaving department of a textile factory were observed. The work observed in this section is done manually by the workers. Figure 1 shows the process of the textile worker wrapping the fabric on a 2-layer roll, Figure 2 shows the process of cutting the rolled fabric, and Figure 3 shows the process of carrying the fabric roll to the loom.

a b c

Figure 1. Working postures of textile workers, a) Fabric wrapping process, b) Cutting the fabric in roll form, and c) Transporting the fabric roll to the loom

In the REBA method, the group A components used to obtain the A score, in which the trunk, neck, and legs are analyzed, are shown in Table 1 [28]. When evaluating the A score in the REBA method according to Table 1, more than 20° flexion (3 points) was observed in the worker's body, especially during fabric wrapping and cutting operations. In addition, since the trunk was exposed to rotation and bending, +1 more points were added, making the trunk score 4. When the neck part was examined, the score was 2 because more than 20° of flexion was observed during the wrapping and cutting. In addition, since there is a lateral rotation movement in the neck, +1 is added to the score. Thus, the neck score was found to be 3. Since flexion between 30° and 60° was observed in the legs, the leg score was 1. When these values were examined in the Group A table in Table 5, the A score was obtained as 6.

Table 5. Group A table [28]

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

Table 3 below shows the Load/Force Score Table. Since the fabric roll carried by the employee to the loom weighs more than 10 kg, 2 more points are added to the score, and the final A score is 8.

In the REBA method, the group B components used to analyze the upper arms, lower arms, and wrists are analyzed, are shown in Table 2 [28]. When evaluating the B score in the REBA method according to Table 2, 20°-45° flexion (2 points) was observed in the worker's upper arm during the fabric wrapping and cutting operations. When the lower arm was examined, flexion between 60° and 100° (1 point) was observed in the lower arm during fabric wrapping, cutting, and carrying the fabric roll. The wrist position was between 0° - 15° (1 point). In addition, since the wrist made a side rotation movement, 1 more point was added, and the wrist score was found to be 2. When these values were examined according to Table 2, the B score was reached as 2. Finally, when the Group B table in Table 6 was discussed, the B score was obtained as 2.

Table 6. Group B table [28]

		Lower Arms					
		1 ♦			2		
	Wrists	1	2 ♦	3	1	2	3
Upper Arms	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

Table 4 below shows the Coupling Score Table. The worker's coupling difficulty was moderate; therefore, the medium-level coupling score (+1) is added to the B score, resulting in a final B score of 3.

As a result of these data, the C score is calculated by the intersection of A and B scores. The employee's C score is 8, according to Table 7. In addition, since the employee remained in a static position for a certain period, +1 is added as an activity score since there is a repeated short interval cutting movement. As a result, the REBA score is found to be 10. A REBA score of 10 indicates a high ergonomic risk level and that changes are urgently needed. This means that the job or task being assessed poses a serious ergonomic risk and requires intervention. In such a case, ergonomic interventions such as reorganizing the work, improving the employees' positions, and making the equipment in the workplace suitable should be made. This type of score requires rapid intervention in the short term [28]. When the studies in the literature are examined, ergonomic risk changes according to the nature of the work. Yavuz et al. [30] conducted an ergonomic risk assessment on an apparel workshop employee in the textile sector. In their study, the REBA score for a fabric-cutting employee is 6. This figure means "medium risk and requiring precautions" according to the REBA method. In addition, in the study, the apparel workshop employees' actions were examined in the fabric cutting section and the quality-control, packaging, ironing, and stain removal sections with REBA and RULA methods.

Table 7. Table C [28]

SCORE A	SCORE B											
	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 ♦	If one or more body parts are static, for example, holding for more than 1 minute
+ 1 ♦	If there are repeated short-interval actions, for example, more than 4 repetitions (excluding walking)
+ 1	If the action causes rapid major changes in posture or unstable posture

4. Conclusion

In this study, an ergonomic risk analysis was conducted by taking into account a worker's movements in the weaving department, where risky worker movements are frequently observed. The study aims to reveal the ergonomic risks in the weaving department and to indicate the necessary precautions to eliminate risky movements. The study determined potential risk factors and ergonomic strain levels to which workers are exposed. Some precautions can be taken when acceptable limit values are exceeded and are specified, and suggestions are made. Using the REBA method, the A score was found to be 8, the B score was found to be 3, and as a result of both, the C score, the REBA score, was found to be 10, including the activity score. When the action levels are examined in the REBA method if the REBA score is 1, ergonomic risks are negligible, and no change is required; if the score is between 2-3, there is a low ergonomic risk level, change is possible but not mandatory; if the score is between 4-7, there is a medium risk, detailed examinations should be made, and changes should be made; if the score is between 8-10, there is a high ergonomic risk, changes should be made in the short term; if the score is more than 10, there is a very high ergonomic risk, changes should be made urgently. Since the score, according to Table 7, indicates a high-risk level, it shows that the necessary measures should be taken in a short time, and the working conditions should be improved ergonomically.

Repetitive movements and constant use of the same muscle groups by workers in weaving units in textile factories lead to musculoskeletal disorders. Such disorders cause strain in areas such as hands, arms, wrists, and shoulders. According to the analysis results of group A and B components in the study, if the movements that cause flexion in the body are long-term and repetitive, they will negatively affect the employee's health if the necessary precautions are not taken. As seen in Figure 1, when wrapping, cutting, and carrying the fabric, the worker's body is in challenging positions, such as bending forward, reaching out, and twisting. This situation can lead to chronic pain and injuries, especially in the waist and back area, for those working in this department. In addition, working standing for long periods is also common in weaving departments. This condition can cause pain in the legs, knees, and lower back and, over time, can lead to circulation problems such as varicose veins [31]. If proper techniques are not used when transferring fabric rolls to the loom or carrying yarn bobbins in weaving departments, such lifting can cause waist and back pain.

In order to reduce ergonomic risks and eliminate employee strain, both employers and employees should take some precautions:

i. Considering the weaving department, it was seen that workers generally carried out the transportation activities manually. Manual material handling is the movement of objects without the assistance of mechanical devices. Manual material handling includes pushing, pulling, carrying, lifting, and lowering. Manual material handling accounts for a large percentage of cases of musculoskeletal disorders [32]. Ergonomic equipment and tools can enable workers to carry fabric rolls more easily.

ii. In this department, workers generally perform activities by standing for long periods. Having a chair where workers can sit from time to time to rest and avoid repetitive movements can help reduce MSDs and ergonomic risks that may occur.

iii. Task rotations can be applied to balance the workload on employees.

iv. Workers can be trained in ergonomics and informed about correct positions and movements.

v. Workers can be encouraged to rest and take breaks regularly because frequent breaks are extremely important to avoid repetitive movements.

vi. Workers and employers should cooperate to improve ergonomics by considering workers' feedback on ergonomic issues. Ergonomic risk assessments such as REBA should be conducted, risks should be identified, and appropriate measures should be taken.

vii. An automatic cutting device can also be installed to prevent workers from bending and turning while cutting the fabric. Although this may seem like a cost to the employer in the short term, it will provide gains for employees in the long term, especially by preventing ergonomic problems.

Author Contributions

The first author collected and analyzed data from the factory. The second author planned and designed the study. This paper is derived from the first author's master's thesis, supervised by the second author. They all read and approved the final version of the paper.

Conflicts of Interest

All the authors declare no conflict of interest.

Ethical Review and Approval

The research was reviewed and approved by the Board of Ethics of Istanbul Gedik University. Approval Number: E-56365223-050.04.

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