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Investigation of the impact of adjustable workstations on ergonomic performance and worker health in furniture assembly

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Abstract: The objective of this study is to ascertain the impact of workbench height on the reduction of physical strain experienced by workers in the furniture industry. The research comprises three distinct phases, to be conducted within a furniture factory setting. The initial phase of the study entails the administration of a comprehensive questionnaire to all production units, with the objective of assessing the degree of physical strain experienced by workers. In the second phase, the Dutch Musculoskeletal Questionnaire (DMQ) and the Rapid Whole-body Assessment (REBA) method were employed in conjunction with one another, with due consideration given to the findings of the preceding phase. This phase was specifically designed to facilitate a comparison between employees who utilize height-adjustable desks and those who do not. The third phase saw the strategic application of the REBA analysis to assembly and final inspection areas that had been identified as hotspots for musculoskeletal disorders complaints. This targeted approach provides a detailed understanding of the ergonomic dynamics of assembly processes, particularly in areas of increased physical strain. The results of these three phases collectively highlight a significant finding: the correlation between worker orientation and workbench height emerges as a crucial ergonomic factor. Adjusting this correlation can play a pivotal role in preventing the onset of musculoskeletal disorders (MSDs), particularly in occupations involving significant physical exertion.
Keywords: Ergonomics, Furniture assembly, Musculoskeletal disorders, Occupational health, Workbench adjustment

Mobilya montajında ayarlanabilir iş istasyonlarının ergonomik performans ve işçi sağlığı üzerindeki etkisinin araştırılması

Öz: Bu çalışmanın amacı, çalışma tezgahı yüksekliğinin mobilya endüstrisindeki işçilerin yaşadığı fiziksel zorlanmanın azaltılması üzerindeki etkisini belirlemektir. Araştırma, bir mobilya fabrikası ortamında yürütülecek üç ayrı aşamadan oluşmaktadır. Çalışmanın ilk aşaması, işçilerin yaşadığı fiziksel zorlanma derecesini değerlendirme amacıyla tüm üretim birimlerine kapsamlı bir anket uygulanmasını içerir. İkinci aşamada, Hollanda Kas-İskelet Sistemi Anketi ve Hızlı Tüm Vücut Değerlendirmesi yöntemi, önceki aşamanın bulgularına gereken önem verilerek birlikte kullanılmıştır. Bu aşama, yüksekliği ayarlanabilir masaları kullanan ve kullanmayan çalışanlar arasında bir karşılaştırmayı kolaylaştırmak için özel olarak tasarlanmıştır. Üçüncü aşamada, REBA analizinin, MSD şikayetleri için sıcak noktalar olarak belirlenen montaj ve son muayene alanlarına stratejik olarak uygulanması görülmüştür. Bu hedefli yaklaşım, özellikle artan fiziksel zorlanma alanlarında montaj süreçlerinin ergonomik dinamikleri hakkında ayrıntılı bir anlayış sağladı. Bu üç aşamanın sonuçları toplu olarak önemli bir bulguyu vurgulamaktadır: işçi yönelimi ile tezgah yüksekliği arasındaki ilişki, önemli bir ergonomik faktör olarak ortaya çıkmaktadır. Bu ilişkiyi ayarlamak, özellikle önemli fiziksel efor gerektiren mesleklerde, kas-iskelet sistemi bozukluklarının başlamasını önlemede önemli bir rol oynayabilir.
Anahtar kelimeler: Ergonomi, Mobilya montajı, İş sağlığı, Kas iskelet sistemi rahatsızlıkları, Çalışma tezgahı ayarlama

1. Introduction

The integration of machinery and technology in production sectors, commonly referred to as Industry 4.0 or the fourth industrial revolution, has been a defining trend in recent decades. The furniture industry has witnessed significant enhancements in efficiency, precision, and speed through automation, robotics, and advanced technologies. However, a combination of automated processes and skilled human labor remains essential in the industry (Hirsch-Kreinsen, 2016; Xiong et al., 2023). Although machinery enhances efficiency and standardization, human involvement is indispensable for tasks that require creativity, customization, quality control, and adaptability to changing trends and customer preferences (Gao et al., 2015; Xiong et al., 2023).

Exposure to demanding work conditions in the furniture industry may result in a range of musculoskeletal issues among workers (Gao et al., 2015; Jain et al., 2021; Nejad et al., 2013; Thetkathuek and Meepradit, 2018). Repetitive motions (Chan et al., 2020; Kumar, 2001; Lim et al., 2021), such as those required for sanding, cutting, or assembly, can lead to conditions like carpal tunnel syndrome (Dabbagh et al., 2021; Moro-López-Menchero et al., 2023; Roquelaure et

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al., 2020) or tendon injuries (Dickson et al., 2023; García et al., 2020; Mehrzad et al., 2022). Heavy lifting (Friedenberg et al., 2022; García et al., 2020) without proper ergonomic practices causes back injuries (Forde and Buchholz, 2004; Fouladi-Dehaghi et al., 2021; Subedi and Pradhananga, 2021) and strain on the spine (Arora and Khatri, 2022; Mavrin Jeličić et al., 2022; Ramanandi and Desai, 2021), and improper postures maintained for prolonged periods can cause muscle imbalances, joint pain, and decreased flexibility.

Studies have shown that pain and discomfort in various parts of the musculoskeletal system are major problems in the workplace, and musculoskeletal disorders are the cause of more than half of workplace absences. Musculoskeletal problems rank second after occupational respiratory diseases among work-related diseases and complaints, as classified by the national institute for occupational safety and health (NIOSH) (Al-Hawari et al., 2014; Bernal et al., 2015; Boschman et al., 2012; Fouladi-Dehaghi et al., 2021; Haeffner et al., 2018).

Ergonomic risk control at manual workplaces (Al-Hawari et al., 2014) is not only a legal obligation but also a matter of employee health care and economic consideration. In the realm of employee well-being, it is incumbent upon workplaces to incorporate techniques for forecasting and averting ergonomic hazards into their day-to-day operations. Employers can utilize the Rapid Entire Body Assessment (REBA) as a valuable tool to assess and enhance workplace ergonomics. REBA is designed to evaluate the ergonomic risk factors associated with various job tasks, helping employers identify potential issues that may lead to musculoskeletal disorders (MSDs) among workers (Erginel and Toptanci, 2019; Kee, 2021; Kodle et al., 2023; Yalcin Kavus et al., 2023). Through the use of REBA, they can systematically analyse different workstations, postures and work processes to determine the level of risk to employees.

In the domain of furniture assembly, workers are likewise exposed to a substantial risk of developing musculoskeletal disorders (MSDs) as a consequence of the repetitive nature of the job. The constant and repetitive movements demanded by the assembly process, including the tightening of screws and installation of furniture components, can result in cumulative trauma and musculoskeletal strain over time. Furthermore, the requirement to lift heavy furniture pieces, particularly larger or bulkier ones, increases the likelihood of back injuries and other related issues. Since the furniture to be assembled have different shapes and sizes, compulsive and constantly changing body movements are performed during the assembly of the parts (Jain et al., 2021; Nejad et al., 2013; Özkaya et al., 2018; Singh et al., 2021; Thetkathuek and Meepradit, 2018). Assembly workers may also be required to maintain awkward postures while manipulating and assembling various parts, and prolonged periods of standing can contribute to fatigue and discomfort. The pressure to meet tight deadlines and quotas in furniture assembly often encourages workers to prioritize speed over proper body mechanics, exacerbating the risk of musculoskeletal issues.

In recent years, ergonomic aspects of assembly design problems have been addressed from various perspectives to reduce work-related MSDs. Gönen et al. (2018) proposed a new risk assessment method to calculate which body parts of assembly line workers are at risk. Finco et al. (2019) recommended reducing the negative effects of using vibratory tools on the assembly line. Dimitrokalli et al. (2020) experimentally demonstrated that using robots on the assembly line has positive contributions. Liau and Ryu (2020) have created a mathematical model to show the benefits of human-robot cooperation in mold assemblies where heavy parts transportation is intensive. Wilhelm et al. (2021) introduced the concept of ErgoTact and developed a human-oriented balancing model between production time and ergonomic work in manual assembly lines. Buisseret et al. (2018) developed low-cost software with high reliability and supported by 3D cameras instead of ergonomic risk analyses based on employee video recordings and observation. Wang et al. (2021) modeled an estimation method supported by an artificial intelligence algorithm to measure the musculoskeletal system (MSS) strains more precisely on the worker in motion. Oyekan et al. (2021) have designed a wearable sensor system to analyze the ergonomic situations of workers working where manual assembly labor is intensive in real-time. Singh et al. (2022) reduced the time spent for assembly on the concrete mixer machine assembly line, increased the work efficiency of the operator, product delivery and quality, and work safety, and revealed that as a result, the risk of MSDs was reduced by 63.7%. In this context, this case study examined the effectiveness of height-adjustable workbenches in reducing the risk of musculoskeletal disorders (MSDs) among workers in the furniture assembly industry who frequently perform work that requires bending.

2. Material and methods

The cross-sectional study was systematically performed in three phases using a deductive approach in a large-scale furniture manufacturing company in November 2023. This facility comprises six distinct production units: solid wood processing, plate processing, surface treatment, assembly, quality control (final inspection), and packaging. As a certified entity by the Forest Stewardship Council (FSC), situated in the Denizli province of Türkiye and established in 1974, the factory has garnered recognition through environmental, quality, and export accolades.

The study was meticulously planned in three sequential and interdependent stages. This tripartite methodology was designed to holistically explore and interpret the intricate interplay of variables across the distinct stages of the research, thereby contributing to a nuanced and comprehensive understanding of the study's key objectives. Indeed, this multi-stage approach aimed to comprehensively evaluate and address occupational health and safety concerns within the specified furniture work units.

First stage, a carefully designed and comprehensive questionnaire of 143 items was developed and administered to a cohort of 115 randomly selected participants, including 5 women, all of whom volunteered to participate in the study. The survey includes data on the employee and their job role, details describing the work environment and inherent risk factors associated with the job, and parts describing the individual's work environment and job satisfaction.

The second stage started with four units (surface treatments, assembly, quality control, and packaging) where labor-based work is produced, and the use of height-adjustable workbenches is partially made. In this stage, a targeted re-survey was undertaken, involving a subset of 54 randomly selected participants, 3 female individuals. Dutch Musculoskeletal Questionnaire (DMQ), designed by

Hildebrandt et al. (2001), is an assessment tool that is valid and reliable for 24 different occupational groups and can be applied to workers in all occupational groups in general In all versions of the questionnaire, in which three different versions of which were developed, the workload of the MSS for body regions, working conditions that may create risks, and symptoms of MSDs are questioned. The questionnaire examines working conditions that may pose musculoskeletal risks separately for standing, sitting, walking, and uncomfortable postures. Adaptation of the short version of the questionnaire to Turkish and reliability analysis was tested in the doctoral thesis study conducted by Akgöl (2016) (Cronbach's Alpha level was 0.853 for the initial assessment, 0.838 for retesting).

Final stage, a Rapid Entire Body Assessment (REBA) analysis was executed on a selected subset of 15 randomly selected participants, with one female participant included in this subgroup. This study incorporated Reba analysis to assess the risk scores related to work postures, both prior to and after the introduction of a height-adjustable workbench (HAB) intervention, with specific attention directed toward the assembly station (Figure 1). The REBA analysis involved capturing snapshots at 3-second intervals from 15-minute videos recorded on various days and times. The assessment focused on identifying the most frequently recurring movements within these snapshots for comprehensive evaluation.

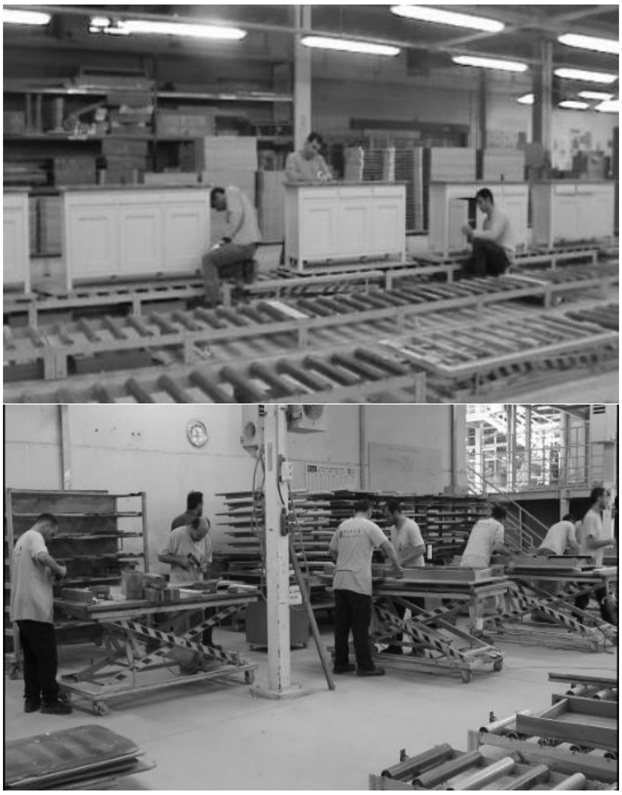

Figure 1. Working postures of workers using and not using HAB in assembly and quality control departments.

The Rapid Entire Body Assessment (REBA) method, developed by Hignett and McAtamney (2000), provides a practical framework for comprehensive analysis of the whole body. This method provides a numerical expression of the risk associated with specific work postures or movements that require analysis. The REBA method assigns a score from 1 to 15, taking into account factors such as flexion and extension of the trunk, neck, legs, upper arms, forearms and wrists during a particular work posture, together with the associated loads carried by the worker during these postures (Figure 2). Based on these scores, ergonomic adjustments are determined, guided by the perceived level of risk to the worker due to the nature of the movements performed during the work (Table 1).

Table 1. REBA action levels (Hignett and McAtamney, 2000)

Action level	REBA score	Risk level	Action (including further assessment)
0	1	Negligible	Nonnecessary
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

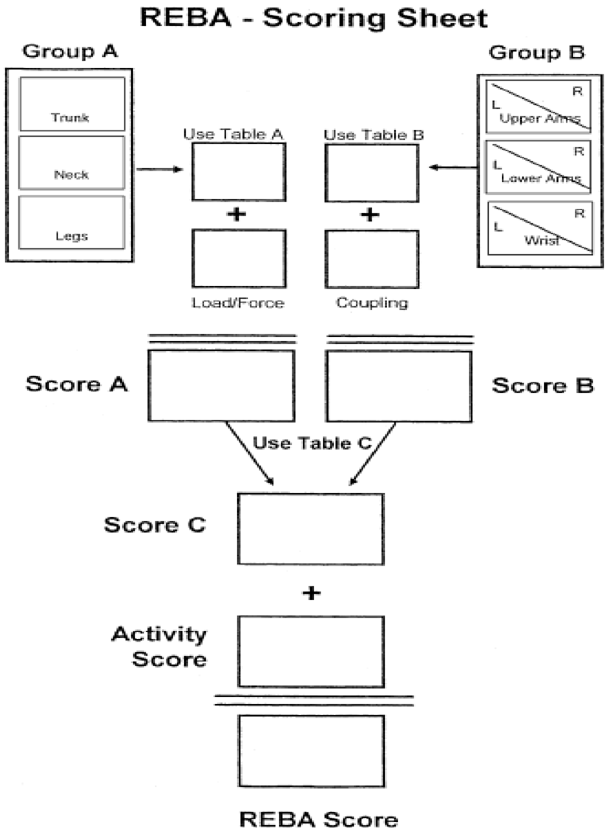

Figure 2. Reba score sheet (Hignett and McAtamney, 2000)

Permission was obtained from the company in order to conduct a study with its employees in accordance with ethical rules. The workers participating in the research were informed.

3. Results

3.1. Stage one: Survey study

One hundred and fifteen employees, five women and 110 men, took part in the first survey, which covered all production units and consisted of 143 questions. It was found that 24.3% of the participants were between 18 and 25 years old, 57.4% were between 26 and 40 years old and 18.3% were over 41 years old. The highest age among them was 50 and the lowest was 21. It was also found that 44.3% had worked in the company for 0-5 years, 27.0% for 6-10 years, 20.9% for 11-15 years, 4.3% for 16-20 years and 3.5% for 21 years and over. The majority of respondents (55.7%) had been with the company for more than five years. This ratio was considered sufficient to provide meaningful answers to the survey questions in terms of work experience and adaptation to the company's working environment. It was found that participants had a maximum of 32 years of work experience and a minimum of 6 months of work experience in the company.

About half (49.6%) of the employees participating in the survey stated that they do not use HAB. In addition, all employees who do not use HAB stated that at least one part of their bodies were affected (such as strain or constant pain), whilst employees who use HAB stated that they did not experience any effects on their bodies. Based on this, a pairwise comparison of the questions was assessed among the survey questions, "Can the height of the unit x workbench or table you work at be adjusted?". According to the regression analysis carried out, it was discovered that there is a statistically significant correlation between the units worked and the height of the workbench (χ Dec2: 46,281; P: 0.000). Table 2 lists the affected body parts of the employees who do not use HAB.

According to the results of the survey presented in Table 2, it was observed that employees do not have many problems with the height of the worktables as technological machines were used in solid wood and panel processing departments. HAB is partly used in surface finishing, assembly and packaging units, among others, but not in quality control units. The parts of the body most affected by workers not using HAB were elbows - forearms - hands (12.2%), knees - hips (11.3%) and neck - shoulders - upper back (10.4%). These results determined that the workers working in the surface finishing, assembly, quality control, and packaging units, which are among the units where the questionnaire was applied, had more strain on their bodies. Accordingly, it was decided to focus on these units in the second stage of the research.

3.2. Stage two: Survey work

The Dutch Musculoskeletal System Questionnaire (DMQ - TR - k) was employed during the study's second stage. 66.67% of the 54 respondents, comprising 51 men and 3 women, were between the ages of 26 and 40. With respect to education level, 53.70% were primary school graduates and 42.59% were high school graduates. As per the BMI analysis, 50% were overweight (25.00-29.99 kg/m^2) and 44.44% were in the ideal range (18.50-24.99 kg/m^2). It is important that workers are not in the underweight or obese category as the job requires physical strength. It has been observed that 51.85% have 0-5 years of experience and 31.48% have 6-10 years of experience related to their work. Based on these results, it has been determined that the majority of the workers participating in the survey are in the active working age range and have limited professional experience.

38.89% of the respondents answered the question "Do you squat while working?" as frequently, 46.30% of the respondents answered the question "Do you have a work situation where you bend over while working?" as frequently, 33.33% of the respondents answered the question "Do you have a situation where you carry more than one workpiece/furniture while working?

The questions about the working environment that showed a statistically significant relationship ($p<0.05$) in the pairwise comparison analyses between the questions in the questionnaire are listed in the tables (Table 3, Table 4, Table 5).

Table 3 shows that the use of raised workbenches (HAB) and sitting on stools is very common in assembly and quality control units. When these units were examined, it was found that the use of HAB was partial, and that sedentary work was carried out in the same positions for long periods of time. In addition, it was observed that workers in the "assembly" and "quality control" units, where HAB is not used, need stools depending on the volume of furniture produced, and that HAB is mainly used when working on furniture with small volumes (height below waist level). It has been observed that there is a lot of body movement during operations in the "varnish/paint", "sanding" and "packing" units, where the use of stools is minimal, and therefore sitting is not much preferred by the workers. In addition, it was observed that workers in the "assembly" and "quality control" units, where HAB is not used, need stools depending on the volume of furniture produced, and that HAB is mainly used when working on furniture with small volumes (height below waist level). It has been noted that there is a lot of body movement during operations in the "varnish/paint", "sanding" and "packing" units, where the use of stools is minimal, and therefore sitting is not much preferred by the workers.

Table 2. The relationship between the working unit and the use of a height-adjustable workbench

Unit of worked	Can the height of the workbench or table be adjusted? — No: Affected/Strained body part — Neck, shoulders and upper back	Elbow, forearm and hands	Feet	Knee and Hip	Back	Total	Yes: Employee who does not indicate a problem	Total employee
Solid wood processing	-	-	2	1	-	3	16	19 (16.5%)
Panel processing	-	-	7	5	-	12	35	47 (40.9%)
Surface finishing	7	4	-	7	-	18	2	20 (17.4%)
Assembly	3	7	-	-	3	13	4	17 (14.8%)
Quality control	1	2	-	-	2	5	-	5 (4.3%)
Packaging	1	1	-	-	4	6	1	7 (6.1%)
Total	12 (10.4%)	14 (12.2%)	9 (7.8%)	13 (11.3%)	9 (7.8%)	**57 (49.6%)**	**58 (50.4%)**	**115 (100%)**

Table 3. Significant relationship between equipment used in the work environment and work units (p< 0.05)

		Worked Units: VP	S	A	QC	PK	T
Do you work on the raised workbench while working? (χ^2 = 24.247; *p* = 0.019)	I	2	3	2	2	0	9 (16.67%)
	II	0	1	1	2	3	7 (12.96%)
	III	4	0	10	6	1	21 (38.89%)
	IV	3	4	7	3	0	17 (31.48%)
	T	9	8	20	13	4	54 (100%)
Do you have a situation of working by sitting on a stool while working? (χ^2 = 25.233; *p* = 0.014)	I	6	7	10	2	2	22 (40.74%)
	II	2	1	4	8	2	22 (40.74%)
	III	0	0	5	1	0	6 (11.11%)
	IV	1	0	1	2	0	4 (7.41%)
	T	9	8	20	13	4	54 (100%)

Note: VP: Varnish/Paint, S: Sanding, A: Assembly, QC: Quality Control, PK: Packing, T: Total, I: Never, II: Several times, III: Often, IV: Constantly

Table 4. Significant relationship between age and health problems experienced in the last 12 months (*p*<0.05)

(χ^2 = 93.209; *p* = 0.047)		Degree of Frequency	AGE: 18-25 Years Old	26-40 Years Old	41-60 Years Old	Total
Have you had any complaints (pain, disorder) in the last 12 months?	Neck	A few times	0	**10**	**5**	**15**
		Often	2	4	3	9
	Back	A few times	0	7	3	10
		Often	3	5	1	9
	Back	A few times	1	**12**	3	**16**
		Often	4	10	4	**18**
	Left Shoulder	A few times	0	2	1	3
		Often	0	4	2	6
	Right Shoulder	A few times	0	5	0	5
		Often	1	3	3	7
	Left Elbow	A few times	1	3	0	4
		Often	0	3	1	4
	Right Elbow	A few times	1	5	0	6
		Often	0	2	1	3
	Left Wrist/Hand	A few times	1	5	**4**	10
		Often	0	5	0	5
	Right Wrist/Hand	A few times	1	6	**4**	11
		Often	0	4	0	4
	Left Hip/ Thigh	A few times	0	6	0	6
		Often	2	2	0	4
	Right Hip/ Thigh	A few times	0	7	0	7
		Often	1	1	0	2
	Left Knee	A few times	1	6	2	9
		Often	0	4	1	5
	Right Knee	A few times	1	7	1	9
		Often	1	2	2	5
	Left Ankle/Foot	A few times	0	6	2	8
		Often	1	4	0	5
	Right Ankle/Foot	A few times	0	7	1	8
		Often	1	4	0	5
I Have No Complaints / At All			2	**10**	0	12
		Total	25	**161**	44	230

Table 4 shows that those who experienced the most health problems in the last 12 months were employees aged 26-40, i.e. the active working age group. The waist, neck and back stand out as the areas with the most health problems. Neck and back problems were found to be more common among workers aged 41-60. This result is similar to the findings of Asadi et al. (2019) on aircraft maintenance workers working in an irregular working environment.

According to the correlation analysis shown in Table 5, it was observed that employees who have completed primary and secondary education describe their jobs as heavy and difficult. It can be concluded that as the level of education increases, the quality of the employees rises, and they are employed in jobs with less workload.

3.3. The third stage: Reba analysis

The postures of the workers were analyzed ergonomically while performing the same work with and without the use of a workbench in the "assembly" and "quality control" units, which were identified as the places where HABs were partially used.

3.3.1. Final assembly station REBA Analysis

Figure 3 shows the REBA analysis scores of workers working in areas without HABs. Example images are shown in Figure 3 according to the REBA scores, where the density occurs in 15 images that were scored as different from each other during work. Due to the lack of workbenches in the work area, the REBA scores were concentrated in the 3rd and 4th levels, which are considered high and very high, as the workers mostly work in a bent position.

Table 5. The significant relationship between the degree of difficulty of the work you do in your daily work pace and education

(χ^2 = 21.280; p = 0.046)	The degree of difficulty of the work you do in your daily work pace				
Education	Lightweight/Easy	Normal	Heavy/Difficult	Too Heavy/Too Hard	Total
Primary school	1	11	11	6	29
High school	0	10	11	2	23
University/associate degree	0	0	1	0	1
University/Undergraduate	0	0	0	1	1
Total	1	21	23	9	54

REBA Score: 11 REBA Score: 9 REBA Score: 11

Figure 3. Reba scores of working postures before HAB use at the final assembly station

REBA Score: 5 REBA Score: 3 REBA Score: 5

Figure 4. Reba scores of working postures after workbench use at the final assembly station

Figure 4 shows the Reba analysis, scores of the workers in the areas where HABs are used. Using the height-adjustable workbench reduces the Reba scores to the 1st and 2nd levels. The use of HABs of this workstation showed significant benefits.

3.3.2. Quality control (Final control) Station REBA Analysis

Figure 5 shows the postures of the workers in the absence of HABs. Here, workers are bending or squatting for long periods of time due to the delicate retouching and sizing work. Some workers are unable to work for long periods, so they squat and sit on stools. The Reba score increased for this work without the use of a workbench.

Figure 6 shows the REBA analysis scores for workers in areas using HABs. It is clear that the REBA scores decreased, but the use of HABs did not reduce the risk level to the desired level. It can be said that this could be caused by long periods of bending forward and sideways due to sensitive checking and setting in the quality control area. In addition to the use of HAB, functional workbenches can be used to improve the ergonomic working environment. If this is not possible, a redesign of the work in the quality control area can be considered.

4. Discussion and Conclusions

The role of a furniture assembler requires a high degree of precision and meticulous attention to detail. While the REBA method is a relatively recent innovation in the context of furniture assembly, its application in assembly lines is a well-established and widely adopted approach across numerous sectors (Sujatmiko and Akmal, 2024; Drinkaus et al. 2003; Chakravarthy et al., 2015; Qutubuddin et al. 2013a, 2013b). This study has identified a number of potential risks inherent in the assembly process, including repetitive movements, prolonged static postures, and physically demanding tasks, particularly when performed on a stationary assembly line. It would be prudent to focus on the areas of concern affecting the waist, back, and joints, as these have the potential to increase the risk of long-term health problems for workers. In a similar study, Bao et al. (2021) found that even with adequate ergonomic support, physically demanding tasks can lead to fatigue and cellular resource depletion. It is also possible that this situation may apply to furniture assembly workers.

REBA score: 9 REBA score: 9 REBA score: 9

Figure 5. Reba scores of working postures before workbench use at the final control station

REBA score: 4 REBA score: 7 REBA score: 5

Figure 6. Reba scores of work postures after workbench use at the final control station

It may also be worthwhile exploring the potential of adopting robotic applications to reduce the burden on assembly line workers, in line with the findings of Colim et al. (2021), which suggest that such applications could be a valuable step towards improving worker health.

The research indicated that the implementation of ergonomic interventions tailored to the specific needs of the workforce would be advantageous. It is essential to consider the diversity of workers in terms of age, gender and physical abilities when implementing ergonomic solutions. Shikdar and Al-Hadhrami (2012), Ani and Azid (2022) reported that adjustable workstations and tools that adapt to different body sizes and strengths have the potential to reduce the risk of injury and increase overall productivity, which is in line with our findings.

In addition to physical ergonomic solutions, we believe it would be beneficial to address the psychosocial aspects of the work environment. It would be beneficial to consider that high job demands, low job control, and lack of social support can potentially contribute to the physical strain experienced by workers. Therefore, it might be helpful to create a supportive work culture that promotes mental well-being for furniture assembly workers. This could be achieved through regular communication, feedback mechanisms, and opportunities for workers to participate in decision-making processes related to their tasks and work conditions, in line with the findings of Martin et al. (2016).

It is recommended that future research be conducted with a focus on assembly lines with adjustable height workstations, which represents a significant finding of this study. The integration of robotic applications in assembly lines with adjustable height workstations has the potential to eliminate physical strain and fatigue entirely.

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