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Ergonomic Assessment of Working Conditions Among Sewing Machine Operators in Bangladesh

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Abstract

Sewing machine operators play a vital role in the economy by producing export-ready garments. However, the repetitive nature of sewing tasks increases their vulnerability to Musculoskeletal Disorders (MSDs), one of the most common occupational injuries. This study aims to evaluate the major risk factors for MSDs among sewing machine operators in Bangladesh, addressing the lack of ergonomic research in this sector. Key risk factors were identified using chi-square tests. Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) were applied to determine ergonomic risk exposure. The Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) ranked body areas based on total discomfort scores. Alarmingly, 80.72% of workers reported MSDs. The study found significant correlations between musculoskeletal issues and factors such as marital status, BMI, occupational stress, and job satisfaction. RULA and REBA results highlighted the urgent need to address ergonomic concerns. CMDQ findings showed the neck, right shoulder, and lower back as the most affected regions. The authors suggest that these insights will help employers create ergonomic workplaces, thereby improving worker health, mental well-being, and organizational productivity.

Keywords

Musculoskeletal Disorders (MSDs), Sewing machine operators, Ergonomics, Risk factors, RULA, REBA

1. Introduction

Sewing machine operators are those who operate various kinds of sewing machines to carry out garment operations. These operations include joining, reinforcing, or decorating garments and garment parts. Various types of machines, such as single needle lock stitch machines, overlock sewing machines, buttock attaching machines, multi-needle chain stitch machines, etc., are used in performing sewing operations. In a developing country like Bangladesh, where the major portion of GDP originates from exporting ready-made garments, sewing machine operators are considered the vital workforce.

The ready-made clothing sector serves as a crucial catalyst for economic expansion in Bangladesh. Approximately 4,300 garment manufacturers employ around 3.6 million people, with a significant 80% of the workforce being women.(Mithy et al. 2024). Additionally, Bangladesh's garment industry accounts for more than 80% of the country's total exports, making Bangladesh the second country after China when it comes to the export of readymade garments (Haque et al.2023). So, it is compulsory to take a deep look into the work environment where the garment productions are performed. The work conditions in which operations are performed are barely worker friendly. Enhancing the working conditions will help reduce the prevalence of MSDs among the operators, resulting in more productivity.

MSDs are related to muscular, nervous, tendinous, and spinal disorders or injuries (Silverstein & Evanoff 2011). Besides, work-related musculoskeletal disorders (WMSDs) are regarded as situations in which the workplace environment and performance of work contribute largely to the advancement of MSDs. Musculoskeletal disorders in the workplace can be related to various factors, such as insipid tasks, increased work pressure, repetitive tasks, and the temperature of the workplace (Alexopoulos et al., 2003). Working at a sewing machine is marked by lengthy periods of sitting, recurrent work, and a high level of muscle strain on the lower part of the back, upper part of the back, shoulders, arms, wrists, and fingers. As a result, this type of work characteristic contributes largely to the growth of MSDs, such as musculoskeletal, stiffness of the spinal canal, spreading ache from the ischiadic nerve, and inflammation of the tendons (Bulduk et al.2017).

Sewing machine operators are the vital workforce for a developing country like ours. But, due to the existing job characteristics, the performance of the operators degrades, which in turn results in lower productivity for the organization. However, there are quite a few studies related to the MSDs of sewing machine operators in Bangladesh. To the best of our knowledge, there is a lack of statistical analysis incorporated with the use of ergonomic tools in the studies performed on Bangladeshi garment workers. The fundamental purposes of this research are listed below:

- To evaluate the prevalence of musculoskeletal disorders among sewing machine operators
- To determine the total discomfort scores for various parts of the body
- To determine the relationships between musculoskeletal disorders and various factors such as- demographic factors, work characteristics, RULA scores, and REBA scores.

The research study is performed in a well-structured sequence. The ‘Introduction’ section gives a brief overview of the study. ‘Literature review’ is the second section of the study. Findings from the previous studies are discussed briefly in this chapter. The tools and methods used for the research study are also discussed briefly. The third section discusses the methodology of the study. In the subsequent section named ‘Results’, insights gathered from data analysis are discussed. In the fifth section, the findings of the current study are discussed based on the studies performed previously on this domain. Finally, the study finishes with concluding remarks

2. Literature review

In the textile industry, WMSDs are considered one of the key problems in workplaces. A study on Portuguese workers revealed that the major portion of the workers (88.71%) in the Portuguese textile industry were suffering severely from musculoskeletal disorders (Azevedo et al. 2020). The study also disclosed that the lower region of the back, neck, wrists, and shoulders had greater discomfort. The proportions of disorders for those regions were 49.1%, 43.4%, 39.6%, and 37.7%, respectively.A study by Sakthi Nagaraj et al. (2019) on Sri Lankan sewing machine operators indicated that the highest frequency of musculoskeletal discomforts was in the lower region of SSMOs. The research study's findings of the REBA grand score revealed that above 90% of workers were facing a medium level of risk. The outstanding portions were at a large and very large level of risk, indicating the urgency for reconsideration and making changes to the postures at work to minimize disorders permanently. A similar research study by Berberoğlu & Tokuç (2013) in a textile industry showed that the number of WMSD complaints increased with age. At the age of 55-64 years, the number of self-reported symptoms was 1.7 times higher than at the age of 25-34 years.

In a cross-sectional study, performed in Tehran textile industry, the disclosure of risk factors related to MSDs was gauged by quick exposure check (QEC) technique, and the prevalence of musculoskeletal disorders was determined. The study findings indicated that there exists a significant association ($p<0.05$) between age and the incidence of MSDs in the neck and shoulder. Significant association was found between the BMI of workers and MSDs in their wrists and hands ($p= 0.002$), and the lower back part ($p= 0.04$) was also significant (Shoja et al. 2014).

A study in northern Iran, where the target population sample included 566 subjects. Among them, 404 were males (71.4%). Male subjects aged between 23 and 51 years. The rest of the workers were female. The number of female workers was 162 (28.6%). The age of the female sample was between 21 and 37 years. The research study revealed that the incidence of musculoskeletal disorders was the highest in the upper arms. The percentage was as high as 87.8%. whereas a 45.1% incidence was found in the lower arms. The percentage of MSDs in the necks, wrists, trunk, and legs was 67.7%, 56.2%, 77%, and 28.8%, respectively (Moussavi Najarkola & Mirzaei 2012). Another research-based study by Sealetsa & Thatcher (2011) detected and explained potential ergonomics shortcomings in the workplace of workers in a textile industry in Botswana, and their insights into workload and physical discomforts.

A study on Chinese garment workers showed that 8.3% of all workers who took part in the survey reported that they had been suffering from an acute traumatic injury in the past year. Approximately half of the staff members reported that they had been suffering from MSDs in the past year. In those Chinese factories, a high number of frontline employees were impacted by work-related accidents and occupational diseases. The significant factors found in the study were lengthy work duration, history of previous illness, and job stress at work (Yu et al. 2012). In a cross-sectional study conducted in Myanmar, a total of 370 sewing workers were included. According to the study, three hundred forty-seven workers had discomfort in at least one region of their bodies. Moderate ability was discovered in 66.5 percent of the population, with poor ability in 18.4 percent of the population. The logistic regression model revealed that gender, job stress, physical demand, and productivity were the significant factors for MSDs. This discovery may be useful in guiding the enhancement of working conditions for sewing workers in clothing factories as well as the development of rules for the well-being of personnel (Oo 2021).

In a study on garment workers in Malaysia, the authors gathered data using the Nordic Musculoskeletal Questionnaire and the Rapid Upper Limb Assessment, both of which were done using a notebook and a pen. Compared to the time rate wage group, the piece rate wage group had a few breaks, had a higher rate of production needs, and performed at a fast pace. Besides, they felt greater weariness and strain as a result of the increased work demands, as revealed by the study. In addition, they were seen working with more physical disclosure, such as recurrent chores, difficult static stances, uncomfortable grasping and hand motions, dragging, raising, and pressing. Finally, the final scores from the RULA assessment were higher among those earning piece rate wages (72.53%, RULA score 7), reflecting that they were exposed to more job hazards as a result of their employment (Nawawi et al. 2015). Additionally, the results of research by Isler et al. (2018) showed that 49.53 percent of stitching operators' working stances may require ergonomic adjustment at Level 2, while 26.76 percent of stitching operators' working postures require ergonomic alteration at Level 3 as reported by the REBA approach.

Another study in Bangladesh by Jahan et al. (2015) revealed that six of every ten respondents were suffering from musculoskeletal disorders among the garment workers. All of the participants who had MSDs felt pain in various sites. The percentage of pain in neck, lower back and shoulder joints was 36.7%, 22.2%, and 18.9%, respectively and the rest of them had discomfort in the region of elbow, upper back, and hip joint. A comprehensive case study was performed on Bangladeshi garment workers to look at the risk factors related to ergonomics that affect stitch workers in Bangladesh. The study illustrated that the operators operated in an ergonomically hazardous environment, with uncomfortable postures in the neck and back. Repetitive hand and arm activities, sitting for long periods in the same posture, and lengthy working shifts without proper rest intervals were the common hazards. Each of those risk variables had a detrimental influence on physical functioning, health bills, and productivity, as well as the ability to function efficiently in everyday life tasks. The use of ergonomic chairs and workspaces is among the most effective suggestions (Habib 2015).

Comper et al. (2012) aimed to find out the characteristics related to the functionality of textile workers in textile plants. The intensity of disclosure of risk factors was found. The impact of these risk factors on growing musculoskeletal symptoms was also identified. Besides, the study found that the spinal region and limbs of the upper portion had a high percentage of MSDs. Other findings indicated that postural disorders, musculoskeletal symptoms, and risk factors were correlated. WMSDs play a detrimental role in productivity. Absenteeism increases due to MSDs. A research

study in the Danish textile industry revealed that fact. In this working group, the incidence of sick leave was kept to a minimum. Among all participants, 17.8 percent stated that they had missed at least one day of work in the previous year due to musculoskeletal difficulties. These difficulties occurred in various parts of the body, such as the shoulder, arm, neck, and hands. The most prevalent of them was pain in the neck-shoulder region, which accounted for most sick days. 11.9 percent of those surveyed reported having missed at least one day of work owing to neck-shoulder difficulties in the previous year, with 4.7 percent reporting missing eight or more days (Kaergaard & Andersen 2000).

2.1. Tools required for the study

To perform the observational study, the Rapid Upper Limb Assessment (RULA) tool and the Rapid Entire Body Assessment (REBA) tool are adopted. Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) is used to assess total discomfort scores among various parts of the body. IBM SPSS 26.0 is used to perform the required statistical analysis on the raw data.

3. Methodology

The present study consists of four major steps. The results are obtained through a well-structured step-by-step procedure. These steps are listed below-

- Workplace selection
- Data collection
- Reliability test
- Data analysis

3.1. Workplace selection

A garment manufacturing unit situated in Bangladesh was selected to perform the research study. The study was conducted for two months. Around 751 workers were working in the sewing section. Among them, 60% were female workers and 40% were male workers. No worker was employed under 18 years old. The daily work started at 8 AM and continued till 5 PM. A lunch break of 1 hour was provided for the workers. The usual work duration for the worker was 8 hours. In a single day, a worker was not allowed to do overtime for more than 2 hours. No worker was allowed to do overtime after 7 PM.

A suitable sample size was selected for the study. The following equation (1) was used to obtain required sample size for conducting the research study (Charan & Biswas, 2013).

$$Sample\ size = \frac{Z_{1-\frac{\alpha}{2}}{}^2 p(1-p)}{d^2} \tag{1}$$

Here,

$Z_{1-}\alpha$ = standard score (at 95% CI, the value is 1.96)
p = Anticipated percentage in population in accordance with earlier studies
d = Precision value or absolute error

Findings from a previous study indicated that almost 80% of the workers feel discomfort in various regions at their respective workplaces. For a 95% confidence interval, a 5% absolute error, and an 80% expected proportion in the population based on previous studies, the sample size of the workers was roughly 200 (Shupti et al. 2024). A sample size of 249 workers was selected, consisting of both male and female workers, with a 5 percent level of precision and a 95 percent confidence interval. The sample size taken was greater than the estimated sample size. The operators took part voluntarily in the process.

3.2. Data collection

A survey form consisting of questions based on demographics and job-related characteristics was formed. The demographic questionnaire included the operator's age, sex, BMI, marital status, living with children, and education level. The job-related questionnaire included job experience, job satisfaction, and job stress. Some other questions were also included, such as regular exercise and smoking habits. As some of the workers were unable to go through the survey form due to a lack of literacy, they were approached differently. No operator selected for the study was working in a department other than the sewing department. Data was collected in two segments-

- Self-reported study

- Direct observational study

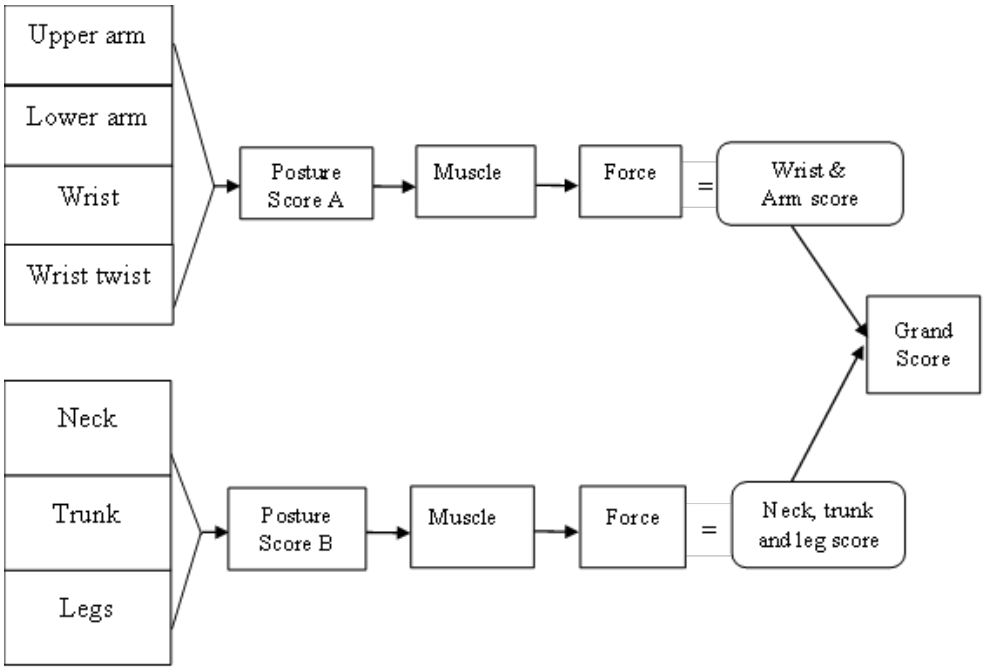
3.2.1. Self-reported Study

A demographic questionnaire, questions on general characteristics, and the CMDQ were listed in a survey form for a self-reported study. The survey questionnaires were set up in Bangla so that answering those questions would become easier for the operators. The data was gathered in such a manner that the productive hours of the company were not hampered. The demographics included sex, age, BMI, marital status, education level, living with children, etc. Some other questions related to MSD, such as daily working duration, job experience, job stress, job satisfaction, etc., were also included in the survey sheet. The SMOs were asked whether they had faced any MSDs during their work period. CMDQ included musculoskeletal discomforts, severity of the discomforts, and interference due to the discomforts associated with 18 body parts for the last week

3.2.2. Direct observational study

The postures of sewing machine operators were gathered from still photographs. The corresponding RULA and REBA scores for SMOs were determined from those still photographs. A number of still photographs of each worker were taken. After that, the photograph with the worst posture was selected to evaluate the RULA and REBA scores of each worker. Various parts of the workers' bodies were observed to determine the RULA and REBA grand scores.

In Figure 1, the process of obtaining the RULA score is shown systematically. It helped the observers to find out the grand score as quickly as possible. Scores of RULA were divided under three distinct groups- "Group A", "Group B", and "RULA grand C". Upper arm, wrist, and lower arm were under Group A. Trunk, neck, and leg were under Group B. The third group was the RULA grand score. Firstly, scores from the upper arm, lower arm, wrist, and wrist twist were obtained to find out posture score A. After that, the muscle score and force score were added to the posture score A to obtain the wrist & arm score. After that, from neck, trunk, and leg scores, posture score B was obtained. After obtaining posture score B, the muscle score and force score were added to the posture B score to obtain the final neck, trunk, and leg score. By using the final scores of wrists and arms, neck, trunk, and legs, a grand score was obtained. A RULA scoring sheet was developed to carry out the procedure.



Source: McAtamney & Nigel Corlett, (1993)
Figure 1. The scoring sheet of RULA

In Figure 1, the process of obtaining the REBA score is shown systematically. It helped the observers to find out the grand score as quickly as possible. Scores of REBA were divided under three distinct groups- "Group A", "Group B", and "REBA grand score". Legs, neck, and trunk were under group A. The wrist, upper arm, and lower arm were under group B. The final score was the REBA grand score. Firstly, scores from the neck, trunk, and legs were obtained to determine posture score A. After that, score A was obtained by counting the force score and the posture score A. After that, from the Upper arm, Lower arm, and Wrist scores, the posture score B was obtained. After that, score B was obtained by adding the coupling score to the posture score B. Then, score C was obtained from scores A and B. A REBA scoring sheet was developed to carry out the procedure.

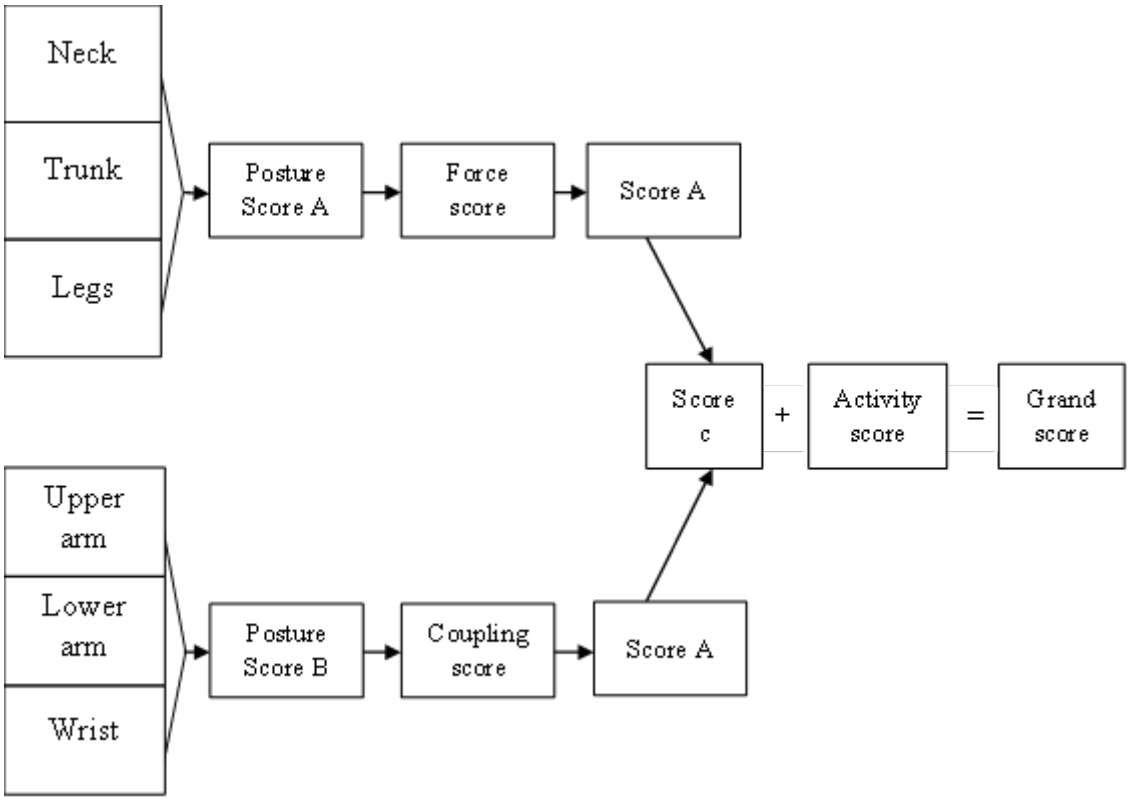


Figure 2. The scoring sheet of REBA (Source: Hignett & McAtamney, (2000))

The required action levels for the RULA grand scores and REBA grand scores are summarized in Tables 1 and 2, respectively.

Table 1. Required action level with respect to RULA grand score

RULA grand score	Required action level
1-2	Negligible risk, no action required
3-4	Low risk, change may be needed
5-6	Medium risk, further investigation, change soon

6+	Very high risk, implement change now

3.3. Reliability and validity test

RULA is a validated tool for assessing various body parts to evaluate the working conditions. In a research study in Turkey, three trained observers observed a total of 93 sewing machine operators individually. Each observer recorded his observations in a form. After that, their observations were compared. After the comparison, it was found that the harmony among the observers ranged from 80% to 86% (Öztürk & Esin, 2011). REBA is also considered a validated tool for assessing the entire body to perform ergonomic evaluation of the workplace. In a study at a Sri Lankan textile industry, an inter-rater reliability test was performed. The value obtained from performing an inter-rater reliability test (Bolin, 2014). The inter-rater reliability REBA score indicated a decent level of reliability among observers. The obtained value of Krippendorff's alpha was above 0.81, providing a good indication of the inter-rater reliability (Sakthi Nagaraj et al., 2019). In this study, Krippendorff's alpha value for the RULA test was 0.83, and the value was 0.924 for the REBA assessment. The findings indicated that the data gathered was reliable.

Table 2. Required action level with respect to REBA grand score

REBA grand score	Required action level
1	Negligible risk, no action required
2-3	Low, action may be necessary
4-7	Medium, action necessary
8-10	High, soon necessary action required
11-15	Very high, immediate actions required

3.4. Data analysis

Data analysis was performed by IBM SPSS Statistics 26.0. Descriptive statistics were gathered from demographic factors and general characteristics. A Chi-squared test was performed to find out significant relationships between MSDs and various factors. Ranking on different parts of the body was determined with the help of CMDQ. The CMDQ is divided into sections of frequencies, severity, and interference. The grading for each section is shown in Table 3. Frequency score, severity score, and interference scores were found by the equation (2)

$$F \text{ or } S \text{ or } I = \sum_{i=1}^{r} n_i R_i \quad (2)$$

Where,

n_i = Workers' overall number for a certain disorder

R_i = Rating value for the corresponding disorder

Chi-square tests were used to assess the significant association between MSDs and variables (demographic and work-related characteristics).

Table 3. Frequency rating, severity rating and interference rating in varying scales

Frequency Rating	Severity Rating	Interference Rating

0 = Not once 1.5 = Weekly 1-2 times 3.5 = weekly 3-2 times 5 = Daily once 10 = several times daily	1 = Somewhat uncomfortable 2 = Pretty uncomfortable 3 = Highly uncomfortable	1 = never 2 = somewhat interfered 3 = largely interfered

4. Results

The results obtained were summarized in three major portions: general characteristics of participants, the relationship between MSDs and various factors, and the ranking of various body parts.

4.1. General characteristics of participants

A total of 249 workers participated in the study. Among them, 146 participants (58.63%) were female workers, and 103 participants (41.37%) were male workers. There were no workers under 18 years old. The general characteristics of the participants are shown in Table 4.

Table 4. General characteristics of sewing machine operators

Characteristics		No. of workers	%
Sex	Male	103	41.37
	Female	146	58.63
Age	<=20	28	11.24
	21-35	144	57.83
	>=36	77	30.92
BMI	Underweight	20	8.03
	Normal	157	63.05
	Overweight	72	28.92
Education level	No Formal Education	62	24.90
	Up to Primary Level (1-5)	90	36.14
	Up to Secondary Level (6-10)	92	36.95
	Above Secondary Level	5	2.01
Marital Status	Unmarried	72	28.92
	Married	177	71.08
Living with children	No	92	36.95
	Yes	157	63.05
Regular exercise	No	218	87.55
	Yes	31	12.45
Smoking habit	No	189	75.90
	Yes	60	24.10
Daily working duration	<=8	118	47.39
	8-10	131	52.61
Job experience	1-5	112	44.98

	>=6	137	55.02
Job stress	Low	24	9.64
	Moderate	175	70.28
	High	50	20.08
Job satisfaction	Low	59	23.69
	Moderate	140	56.22
	High	50	20.08

4.2. RULA and REBA scores

Most of the participants (84.74%) had a RULA grand score greater than 4. On the other hand, the dominant portion of the workers (86.35%) had a REBA grand score between 1 and 7. The RULA scores (score A, score B, grand score) and REBA scores (score A, score B, grand score) were summarized in Table 5.

Table 5. RULA score and REBA score among sewing machine operators

	Characteristics	No. of workers	%
RULA A score	1-4	86	34.54
	>=5	163	65.46
RULA B score	1-4	232	93.17
	>=5	17	6.83
RULA Grand score	1-4	38	15.26
	>=5	211	84.74
REBA A score	1	25	10.04
	2-3	87	34.94
	4-7	137	55.02
REBA B Score	1	45	18.07
	2-3	126	50.60
	4-7	78	31.33
REBA Grand score	1-7	215	86.35
	>=8	34	13.65

4.3. Relationships between MSDs and various factors

The relationship between various factors (sex, age, BMI, marital status, job characteristics, RULA scores, REBA scores, etc.) and MSD symptoms was evaluated. A chi-square test was performed to determine whether there is any significant relationship between a specific factor and MSD symptoms. Chi-square test indicated that the operators' BMI, marital status, smoking habit, job stress, and job satisfaction had a significant relation with MSD symptoms. On the other hand, a significant relationship was not found between MSDs and factors such as age, sex, daily exercise, living with children, education level, job experience, etc. The results are summarized in Table 6. It was found that 80.72% of the workers were suffering from musculoskeletal disorders while working in the sewing department. 81.5% of male workers responded 'Yes' to MSDs. Most female workers also responded positively to pain. A huge portion of married workers (95.48%) were facing MSDs. Most participants had a normal BMI. 97.45% of the operators having normal BMI had responded affirmatively to MSDs. 92.307% of smokers were facing musculoskeletal disorders. The operators having a high level of job stress were more likely to have MSDs. On the other hand, 86.43% of operators having a normal level of satisfaction in their jobs were suffering from MSDs.

Table 6. Various factors and their relations with MSD symptoms

	Independent variables	MSD symptoms		Statistics		
		No 48%	Yes 201%	chi squared value	df	p value
Sex	Male	18.45	81.55	0.078	1	0.780
	Female	19.86	80.14			
Age	<=20	14.29	85.71	0.732	2	0.694
	21-35	20.83	79.17			
	>=36	18.18	81.82			
BMI	Underweight	0.00	100.00	11.98	2	*0.002
	Normal	2.55	97.45			
	Overweight	61.11	38.89			
Education level	No Formal Education	9.68	90.32	0.824	3	0.844
	Up to Primary Level (1-5)	5.56	94.44			
	Up to Secondary Level (6-10)	35.87	64.13			
	Above Secondary Level	80.00	20.00			
Marital status	Unmarried	55.56	44.44	5.668	1	*0.017
	Married	4.52	95.48			
Living with children	No	15.22	84.78	1.545	1	0.214
	Yes	21.66	78.34			
Regular exercise	No	21.10	78.90	3.543	1	0.068
	Yes	6.45	93.55			
Smoking habit	No	23.37	76.63	8.777	1	*0.003
	Yes	7.69	92.31			
Daily working duration	<=8	17.80	82.20	0.316	1	0.574
	8-10	20.61	79.39			
Job experience	1-5	19.64	80.36	0.017	1	0.895
	>=6	18.98	81.02			
Job stress	Low	41.67	58.33	9.544	2	*0.008
	Moderate	18.29	81.71			
	High	12.00	88.00			
Job satisfaction	Low	35.59	64.41	13.368	2	*0.001
	Moderate	13.57	86.43			
	High	16.00	84.00			

The Chi-square test of RULA and REBA scores with musculoskeletal symptoms is summarized in Table 7. A p-value less than .05 was considered an indication of a significant relationship.

Table 7. RULA and REBA scores and their relations with MSDs

Independent variables		MSD symptoms		Statistics		
		No 48%	Yes 201%	chi squared value	df	p value
RULA A score	1-4	12.79	87.21	3.452	1	0.060
	>=5	22.70	77.30			
RULA B score	1-4	13.48	86.52	76.404	1	*0.00001
	>=5	89.47	10.53			
RULA Grand score	1-4	47.37	52.63	22.741	1	*0.0001
	>=5	14.22	85.78			
REBA A score	1	88.00	12.00	4.27	2	0.118
	2-3	26.44	73.56			
	4-7	2.19	97.81			
REBA B score	1	93.33	6.67	3.18	2	0.204
	2-3	2.38	97.62			
	4-7	3.95	96.05			
REBA grand score	1-7	60.00	40.00	5.68	1	*0.017
	>=8	61.76	38.24			

4.4. Prevalence of MSDs among different body parts

. With the help of Cornell Musculoskeletal Discomfort Questionnaires, the frequency of discomforts, the severity of discomforts, and the interference due to discomforts were identified. The results obtained from CMDQ are summarized in Table 8. 76.31% of the workers responded to neck symptoms. Among them, 55.78% felt very uncomfortable during their work. Neck discomfort substantially interfered with the work of 56.31% of workers who responded positively to neck symptoms. 71.89% of the workers responded to the shoulder right symptoms.

Table 8: Prevalence of MSDs among various limbs of the body

Body Parts		Discomfort frequency in previous week					Severity of discomfort			Discomfort interfered with work		
		Not once	Weekly 1-2 times	Weekly 3-4 times	Daily once	Several times daily	Somewhat uncomfortable	Pretty uncomfortable	Highly uncomfortable	Never	Somewhat interfered	Largely interfered
Neck		59 (23.69)	11 (4.41)	33 (13.25)	62 (24.89)	84 (33.73)	20 (10.52)	64 (33.68)	106 (55.78)	22 (11.57)	61 (32.1)	107 (56.31)
Shoulder	Left	74 (29.71)	20 (8.03)	42 (16.86)	52 (20.88)	61 (24.49)	29 (16.57)	56 (32)	90 (51.42)	36 (20.57)	78 (44.57)	61 (34.85)
	Right	70 (28.11)	12 (4.81)	41 (16.46)	64 (25.7)	62 (24.89)	19 (10.55)	65 (36.11)	96 (53.33)	49 (27.22)	71 (39.44)	60 (33.33)
Upper Back		90 (36.14)	43 (17.26)	49 (19.67)	33 (13.25)	34 (13.65)	55 (34.59)	61 (38.36)	43 (27.04)	37 (23.27)	57 (35.84)	65 (40.88)
Upper Arm	Left	85 (34.13)	29 (11.64)	47 (18.87)	47 (18.87)	41 (16.46)	56 (34.14)	69 (42.07)	39 (23.78)	67 (40.85)	64 (39.02)	33 (20.12)
	Right	83 (33.33)	25 (10.04)	47 (18.87)	48 (19.27)	46 (18.47)	51 (30.72)	70 (42.16)	45 (27.1)	61 (36.74)	61 (36.74)	44 (26.5)
Lower Back		66 (26.5)	25 (10.04)	33 (13.25)	47 (18.87)	78 (31.32)	38 (20.76)	47 (25.68)	98 (53.55)	67 (36.61)	62 (33.87)	54 (29.5)
Forearm	Left	77 (30.92)	37 (14.85)	35 (14.05)	48 (19.27)	52 (20.88)	39 (22.67)	42 (24.41)	91 (52.9)	60 (34.88)	68 (39.53)	44 (25.58)
	Right	76 (30.52)	20 (8.03)	46 (18.47)	58 (23.29)	49 (19.67)	26 (15.11)	57 (33.13)	89 (51.74)	25 (14.53)	65 (37.79)	82 (47.67)
Wrist	Left	84 (33.73)	37 (14.85)	42 (16.86)	43 (17.26)	43 (17.26)	38 (23.03)	57 (34.54)	70 (42.42)	39 (23.63)	65 (39.39)	61 (36.96)
	Right	81 (32.53)	28 (11.24)	42 (16.86)	50 (20.08)	48 (19.27)	24 (14.28)	61 (36.3)	83 (49.4)	57 (33.92)	65 (38.69)	46 (27.38)
Hip		86 (34.53)	32 (12.85)	44 (17.67)	45 (18.07)	42 (16.86)	78 (47.85)	66 (40.49)	19 (11.65)	67 (41.1)	63 (38.65)	33 (20.24)
Thigh	Left	93 (37.34)	33 (13.25)	49 (19.67)	41 (16.46)	33 (13.25)	72 (46.15)	58 (37.17)	26 (16.66)	70 (44.87)	56 (35.89)	30 (19.23)
	Right	94 (37.75)	46 (18.47)	54 (21.68)	26 (10.44)	29 (11.64)	59 (38.06)	56 (36.12)	40 (25.8)	43 (27.74)	53 (34.19)	59 (38.06)
Knee	Left	94 (37.75)	28 (11.24)	42 (16.86)	45 (18.07)	40 (16.06)	73 (47.09)	52 (33.54)	30 (19.35)	79 (50.96)	47 (30.32)	29 (18.7)
	Right	98 (39.35)	46 (18.47)	51 (20.48)	28 (11.24)	26 (10.44)	59 (38.81)	69 (45.39)	24 (15.78)	61 (40.13)	59 (38.81)	32 (21.05)
Lower Leg	Left	107 (42.97)	49 (19.67)	54 (21.68)	21 (8.43)	18 (7.22)	69 (48.59)	62 (43.66)	11 (7.74)	61 (42.95)	50 (35.21)	31 (21.83)
	Right	190 (76.3)	41 (16.46)	15 (6.02)	2 (0.8)	1 (0.4)	47 (79.66)	10 (16.94)	2 (3.38)	57 (96.61)	2 (3.38)	0 (0)

7%

uency, severity, interference

nforts

t	% of overall discomfort score	Grade
80	14.85	1
75	8.63	4
91	9.55	2
16	4.19	10

Upper Arm	Left	853	311	294	77993202	4.17	11
	Right	902	326	315	92626380	4.95	9
Lower Back		1168	426	353	175641504	9.39	3
Forearm	Left	938	396	328	121834944	6.51	6
	Right	971	407	401	158473997	8.47	5
Wrist	Left	847.5	362	352	107991840	5.77	8
	Right	919	395	325	117976625	6.31	7
Hip		847	267	292	66035508	3.53	12
Thigh	Left	756	266	272	54698112	2.92	15
	Right	678	291	326	64319148	3.44	13
Knee	Left	814	267	260	56507880	3.02	14
	Right	647.5	269	275	47898813	2.56	16
Lower Leg	Left	547.5	226	254	31428690	1.68	17
	Right	134	73	61	596702	0.03	18

Scores of frequency, severity, and interference were obtained by using the equation (2). After obtaining these three scores, the total discomfort score was obtained by multiplying these three scores. Eighteen body parts were included for ranking. The body parts with the highest total discomfort score were ranked in a higher position. The percentage of total discomfort score for neck, shoulder right, lower back, shoulder left, and forearm right was 14.85%, 9.55%, 9.39%, 8.63%, and 8.47%, respectively. The neck was ranked at the highest position, indicating that it was the most vulnerable part of the body to musculoskeletal discomfort. From Table 9, it was revealed that the upper parts of the body were more susceptible to discomfort than the lower parts. The percentage of total discomfort score for right lower leg, left lower leg, right knee, and left thigh was, respectively, 0.03%, 1.68%, 2.56%, and 2.92%. The right lower leg was the least vulnerable body part.

5.0 Discussion

The study was performed to find out the proportion of MSDs among the sewing machine operators. The outcome of the study showed that an alarming percentage (80.72%) of the workers were facing musculoskeletal disorders. A study on Portuguese workers revealed that most workers (88.7%) in the textile industry were suffering from MSDs (Azevedo et al., 2020). Dianat et al. (2015) in their research on Iranian sewing machine operators revealed that the rate of MSDs was 79.6%. The study was carried out on 251 operators. Another study carried out to evaluate the prevalence of MSDs among garment workers in Bangladesh revealed that 60.7% of workers were experiencing pain in different parts of their bodies. It was found that MSDs are one of the most common health problems in the sample population (Jahan et al., 2015). A similar study on SMOs was conducted on a Sri Lankan textile company. The sample workers were asked whether they had any types of pain related to musculoskeletal conditions. A significant portion of the workers (81%) felt discomfort in their bodies once or twice in the last week (Sakthi Nagaraj et al. 2019).

The married people were more likely to work overtime as they had to earn not only for themselves but also for their families. Due to overtime, they tended to stay longer in the workplace, which contributed to developing MSDs. The rate of MSDs in underweight workers was the highest. Medical history of illness, job pressure, and use of scissors were found to be significant factors (Öztürk & Esin, 2011). Marital status, job experience, and BMI were identified as significant factors in research performed on Bangladeshi garment workers (Hossain et al., 2018). However, in our study, we did not find any significant relation between job experience and MSDs. A study consisting of a sample size of 150 Bangladeshi workers identified sex, age, and marital status as significant factors (Jahan et al. 2015).

The present study was successful in assessing the relationship between MSDs and sewing machine operators. The study found out that marital status, BMI, smoking habit, job stress, and job satisfaction had a significant relationship with MSDs. Job stress had a p-value of 0.008, which indicated that it was significantly associated with MSDs. This finding is supported by Aftab et al. (2020) revealing that almost 70% of the workers in a textile factory were feeling stressed at their workplaces. However, the level of stress among the workers was different. The study indicated

improvement by minimizing the adverse effects that caused stress. Minimal job stress in the workplace would ensure higher performance.

In this study, 84.74% of the workers had a RULA grand score greater than or equal to 5. This score indicated that high and very high risks are prevalent at the workplace, and necessary measures must be taken as quickly as possible. 13.65% of the workers had a REBA grand score greater than or equal to 8. This value indicates that high and very high levels of risk exist in the workplace. In a study on Iranian garment workers in the sewing section, it was revealed that the presence of musculoskeletal complaints, notably in the upper regions, was quite common. The overall grand score of RULA was 5.7, which indicated that the stitching workplace layout was inadequate, and that most workers required an examination and modifications in their practices as soon as possible (Dianat et al. 2015). The grand score of REBA (4–11) suggested that worker stances were in the medium to extremely high-risk categories, requiring examination in order to make improvements to their workstations (Sakthi Nagaraj et al.2019).

In this study, it was revealed from CMDQ that upper body regions were more prone to musculoskeletal discomfort. The neck, right shoulder, and lower back were the three most vulnerable parts of the body. But the lower parts, such as legs, knees, and hips, were less vulnerable to musculoskeletal pain. However, in a study on Sri Lankan standing sewing machine workers, it was revealed that lower body parts were more likely to face threats of musculoskeletal pain (Sakthi Nagaraj et al., 2019). This difference was because of the postures in which they were working. The present study was performed on sitting sewing machine operators, but that study was conducted on standing sewing machine operators.

Job satisfaction was a significant factor in this study. Job satisfaction is largely dependent on the layout of the workplace. A worker-friendly environment in the workplace increases job satisfaction. But ironically, workplaces are not designed ergonomically. A study on the Bangladesh textile industry revealed the stated fact. The overall height of the chairs and the tables was not suitably designed. The gap between the chair and the table was not appropriate for 11.11% of the operators. 18.51% of the operators felt dissatisfied with the layout of the equipment. A large portion of the workers (62.96%) felt that the workplace was noisy. These factors altogether contributed to dissatisfaction with the job (Tahmidul Islam Molla 2018).

6. Conclusion

The study contributes to a better knowledge of the occurrence of discomforts and risk factors that are associated with ergonomics, which will support the development of measures to guarantee that sewing machine operators operate in lean and ergonomic workplaces. The set of reasons that contribute to developing MSDs among sewing machine operators is not well understood in our country. But this study was able to identify the factors that are significantly associated with MSDs. Job stress, job satisfaction, marital status, smoking habit, and BMI have significant contributions to developing MSDs. Organizations may take alternative approaches so that job pressure is reduced and job satisfaction is increased, resulting in fewer occurrences of MSDs. The study adopted various tools, such as RULA, REBA, and CMDQ, which helped in assessing the risk factors correctly. The present study has found that ergonomic considerations are necessary in current working conditions.

The findings from the present study match previous studies. Previous studies also suggest that ergonomic intervention is necessary for sewing machine operators. Employers must adopt correct measures for the betterment of the workplace. Some controls related to administration, such as rotation of the job, addition of interesting elements to tasks, and longer rest breaks, can be taken for the betterment of current working conditions. Some personal protective equipment can also be provided.

6.1 Limitations of the study

This study was helpful in giving insights to the employer about the improvement of the workplace. It also revealed that necessary changes must be made immediately. However, the study had some limitations. Those limitations are stated below-

Data was gathered from a specific industry. As a result, data may vary with industries

Environmental factors such as vibration, noise, and humidity were not included

6.2 Recommendations for future study

Future research should include environmental factors and concentrate on cost-effective strategies to prevent or mitigate occupational health problems among workers. The authors advocate for a substantial cohort of participants

from many companies to enhance the generalizability of the findings. Additionally, data were collected from a specific garment industry in Dhaka. Industries situated in both urban and rural areas can be taken into account. Education programs related to ergonomics can be devised by considering some environmental and social factors.

Ethical Approval
Ethical approval was taken from the authority with reference No. KUET/CASR/24/45 (02). The authors confirm that the study complies with all regulations.

Human Participant Declaration
The authors confirm that written informed consent was obtained from all participants involved in the study.

Conflict of Interest
The authors declare no financial or personal interests that may have influenced the work presented in this study.

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Data availability statement
No data associated with the study has been deposited into a publicly available repository. The authors confirm that the data supporting the findings of this study are available within the article.

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References
Aftab, A., Amjad, H., Mohammad, M., Nadeem, M., Muhammad, S., & Tareq, A. ,Perceived stress: Role and levels of demographics - A cross-sectional study of textile industry employees. *Industria Textila*, *71*(2),(2020). . https://doi.org/10.35530/IT.071.02.1643

Alexopoulos, E. C., Burdorf, A., & Kalokerinou, A. ,Risk factors for musculoskeletal disorders among nursing personnel in Greek hospitals. *International Archives of Occupational and Environmental Health*, *76*(4),(2003). . https://doi.org/10.1007/s00420-003-0442-9,

Azevedo, J., Costa, S., Moreira-Silva, I., Rodrigues, S., Ventura, N., Cardoso, R., & Seixas, A. , Prevalence of Musculoskeletal Symptoms Among Workers of a Portuguese Textile Industry: Association with Body Mass Index and Work Position. In *Studies in Systems, Decision and Control* (Vol. 277),(2020).. https://doi.org/10.1007/978-3-030-41486-3_49

Berberoğlu, U., & Tokuç, B. ,Work-related musculoskeletal disorders at two textile factories in Edirne, Turkey. *Balkan Medical Journal*, *30*(1),(2013). . https://doi.org/10.5152/balkanmedj.2012.069

Bolin, J. H. (2014). Hayes, Andrew F. ,Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach. New York, NY: The Guilford Press. *Journal of Educational Measurement*, *51*(3). https://doi.org/10.1111/jedm.12050

Bulduk, S., Bulduk, E. Ö., & Süren, T. (2017). Reduction of work-related musculoskeletal risk factors following ergonomics education of sewing machine operators. *International Journal of Occupational Safety and Ergonomics*, *23*(3). https://doi.org/10.1080/10803548.2016.1262321

Charan, J., & Biswas, T. , How to calculate sample size for different study designs in medical research? In *Indian Journal of Psychological Medicine* (Vol. 35, Issue 2),2013. https://doi.org/10.4103/0253-7176.116232

Comper, M. L. C., MacEdo, F., & Padula, R. S. , Musculoskeletal symptoms, postural disorders and occupational risk factors: Correlation analysis. *Work*, *41*(SUPPL.1),(2012). . https://doi.org/10.3233/WOR-2012-0478-2445

Dianat, I., Kord, M., Yahyazade, P., Karimi, M. A., & Stedmon, A. W. (2015). Association of individual and work-related risk factors with musculoskeletal symptoms among Iranian sewing machine operators. *Applied Ergonomics*, *51*. https://doi.org/10.1016/j.apergo.2015.04.017

Habib, M. M. , Ergonomic risk factor identification for sewing machine operators through supervised occupational therapy fieldwork in Bangladesh: A case study. *Work*, *50*(3),2015. https://doi.org/10.3233/WOR-151991

Haque, S., Al Rafi, D. A., Zaman, N., Salman, M., Al Noman, M. A., Nazmul Hoque, M., Bhattacharjee, L., Farquhar, S., Yasmin, S., Mehedi Hasan, M., Hira, F. T. Z., Prithi, A. A., Shammi, S. A., Banu, B., & Hossain, A. Nutritional status of under-five aged children of ready-made garment workers in Bangladesh: A cross-sectional study. *PLoS ONE*, *18*(4 APRIL),2023. https://doi.org/10.1371/journal.pone.0284325

Hignett, S., & McAtamney, L. , Rapid Entire Body Assessment (REBA). *Applied Ergonomics*, *31*(2),2000. https://doi.org/10.1016/S0003-6870(99)00039-3

Hossain, M. D., Aftab, A., Al Imam, M. H., Mahmud, I., Chowdhury, I. A., Kabir, R. I., & Sarker, M. , Prevalence of work related musculoskeletal disorders (WMSDs) and ergonomic risk assessment among readymade garment workers of Bangladesh: A cross sectional study. *PLoS ONE*, *13*(7),2018. https://doi.org/10.1371/journal.pone.0200122

Isler, M., Küçük, M., & Guner, M. , Ergonomic assessment of working postures in clothing sector with scientific observation methods. *International Journal of Clothing Science and Technology*, *30*(6),2018. https://doi.org/10.1108/IJCST-06-2017-0084

Jahan, N., Das, M., Mondal, R., Paul, S., Saha, T., Akhtar, R., Khan, A. M., & Banik, C. , Prevalence of Musculoskeletal Disorders among the Bangladeshi Garments Workers. *SMU Medical Journal*, *2*(1),2015.

Kaergaard, A., & Andersen, J. H. , Musculoskeletal disorders of the neck and shoulders in female sewing machine operators: Prevalence, incidence, and prognosis. *Occupational and Environmental Medicine*, *57*(8),2000. https://doi.org/10.1136/oem.57.8.528

McAtamney, L., & Nigel Corlett, E. , RULA: a survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics*, *24*(2),1993. https://doi.org/10.1016/0003-6870(93)90080-S

Mithy, S. A., Hossain, S., & Afroz, S. , Factors associated with low back pain in ready-made garments workers in Bangladesh. *Bulletin of Faculty of Physical Therapy*, *29*(1), 38,2024.

Moussavi Najarkola, S. A., & Mirzaei, R. , Evaluation of Upper Limb Musculoskeletal Loads due to Posture, Repetition, and Force by Rapid Upper Limb Assessment in a Textile Factory. *Journal of Health Scope*, *1*(1),2012. https://doi.org/10.5812/jhs.4532

Nawawi, R., Deros, B. M., Daruis, D. D. I., Ramli, A., Zein, R. M., & Joseph, L. H. , Effects of payment method on work control, work risk and work-related musculoskeletal health among sewing machine operators. *Journal of Mechanical Engineering and Sciences*, *9,2015*. https://doi.org/10.15282/jmes.9.2015.16.0164

Oo, T. W. , *Work-related musculoskeletal disorders, psychosocial factors, work productivity, and work ability among garment factory workers in Myanmar,2021*.

Öztürk, N., & Esin, M. N. (2011). Investigation of musculoskeletal symptoms and ergonomic risk factors among female sewing machine operators in Turkey. *International Journal of Industrial Ergonomics*, *41*(6). https://doi.org/10.1016/j.ergon.2011.07.001

Sakthi Nagaraj, T., Jeyapaul, R., & Mathiyazhagan, K. ,Evaluation of ergonomic working conditions among standing sewing machine operators in Sri Lanka. *International Journal of Industrial Ergonomics*, *70,2019*. https://doi.org/10.1016/j.ergon.2019.01.006

Sealetsa, O. J., & Thatcher, A. (2011). Ergonomics issues among sewing machine operators in the textile manufacturing industry in Botswana. *Work*, *38*(3),2011. https://doi.org/10.3233/WOR-2011-1131

Shoja, E., Hokmabadi, R., Shoja, M., & Gharaee, M. (2014). Ergonomic evaluation of musculoskeletal disorders risk by quick exposure check technique in a textile industry. *Journal of North Khorasan University of Medical Sciences*, *6*(2),2014. https://doi.org/10.29252/jnkums.6.2.259

Shupti, M. N., Hossain, N. U. I., Fazio, S. A., & Ashik, J. H. , Leveraging graph theory approach for managing design principles for sustainable manufacturing of industry 4.0: A case study of electrical equipment manufacturing industry. *Sustainable Manufacturing and Service Economics*, *3*, 100027,2024. https://doi.org/https://doi.org/10.1016/j.smse.2024.100027

Silverstein, B., & Evanoff, B. , Musculoskeletal disorders. *Occupational and Environmental Health: Recognizing and Preventing Disease and Injury*, 335–365,2011.

Tahmidul Islam Molla. (2018). An Investigation of Work-Related Risk Factors Among Sewing Machine Operators in Bangladesh. *Iowa State University Digital Press*, *October*.

Yu, W., Yu, I. T. S., Li, Z., Wang, X., Sun, T., Lin, H., Wan, S., Qiu, H., & Xie, S. , Work-related injuries and musculoskeletal disorders among factory workers in a major city of China. *Accident Analysis and Prevention*, *48,2012*. https://doi.org/10.1016/j.aap.2012.03.001

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