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Original Research Article

Ergonomic hazards and musculoskeletal health in cotton garment units in and around Kolkata, India

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ABSTRACT

Background: In India the garment industry is a major source of employment, particularly in unorganized sectors where ergonomic standards are often inadequate. Prolonged working stress, repetitive movements, and non-neutral working postures increase the risk of work-related musculoskeletal disorders (MSDs), adversely affecting workers' health and productivity. This study aimed to assess the prevalence of musculoskeletal disorders among cotton garment weavers in and around Kolkata and to evaluate their working postures.
Methods: A cross-sectional study was conducted among 122 cotton garment weavers from selected units in and around Kolkata. Participants selected based on their work experience. Musculoskeletal symptoms were assessed using the Modified Nordic Musculoskeletal Questionnaire, postural risk using RULA, and data were analysed in SPSS v19 using chi-square tests, odds ratios (95% CI), and multivariate logistic regression to identify factors associated with MSDs.
Results: The prevalence of musculoskeletal disorders was high (70-85%), with experienced workers showing significantly higher neck (83.33%) and lower back pain (91.67%). RULA assessment indicated high risk (score 5) in 58.33% of participants, and musculoskeletal symptoms were significantly associated with prolonged working hours, work pressure, extended sitting, and higher RULA scores ($p<0.05$).
Conclusions: Due to poor ergonomic condition workers are experience a high burden of musculoskeletal disorders due to poor ergonomic conditions. Community-based ergonomic interventions, improved workstation design, regulated working hours, and adequate rest breaks are urgently needed to reduce MSD risk and enhance workers' occupational health.

Keywords: Ergonomic, Musculoskeletal disorders, Rapid upper limb assessment

INTRODUCTION

India's apparel sector is a global and Asian leader, boasting competitive advantages like a large, affordable labour pool and inexpensive raw materials. Despite these strengths, the industry faces significant workforce turnover. Production significantly contributes to India's economy, accounting for 7% of industrial output, 2% of GDP, and 15% of export revenue.[1] Garment production units pose high risks for musculoskeletal disorders for garment workers due to a complex physical environment involving rapid piece-rate work and the adoption of unprofessional, uncomfortable, and non-neutral postures. One of the primary causes of long-term sick leave and disability pensions worldwide is MSDs among sewing machine operators and manual handling workers.[2] Lack of proper work environment design among garment workers increases their vulnerability to work-related

musculoskeletal disorders (MSDs) because they often don't understand proper body mechanics or the risks associated with repetitive tasks like cutting, assembling, pressing, and finishing on sewing machines. Common MSDs include carpal tunnel syndrome, muscle, tendon strain, tendonitis, thoracic outlet syndrome, epicondylitis, and back strain. Poor postures, such as a hunched position with a lowered head, are common and heighten MSD risk. Other contributing factors include repetition, forceful movements, contact stress, vibrations, and environmental conditions. The work itself is also demanding, requiring high accuracy and concentration.

In accordance with the WHO, over 1000 million people are employed in small scale industries worldwide. The garment industry being heavily unorganized and run by private establishments highlight about the poor working conditions, low wages and a lack of safety standards in this sector. Previous research emphasized ergonomic workstation design, with one study specifically addressing garment workers.[3-8] Kalinkara et al, Qutbuddin et al., Chikumba and Issa M. et al have highlighted the role of anthropometry in design.[9-13] Gahlot et al, Polat and Kalayci, and Moussavi et al applied the RULA technique for postural risk assessment in the garment industry.[5,14-16] There are some works reported MSD prevalence among garment workers, and discussed workstation design and broader ergonomic issues.[17-19]

Through extensive literature review, it is observed that in large scale garment enterprises, various ergonomic techniques have been applied that focuses on workstation design which reduces postural strain thereby preventing musculoskeletal disorders. But there is a huge scarcity of comprehensive ergonomic studies in unorganized tailoring firms. The authors believe a holistic study in such settings is crucial for owners to implement recommendations, improving worker occupational health, safety, ergonomics, performance, and productivity, especially given the lack of specialist services.[20] This study aims to explore how prevalent musculoskeletal disorders (MSDs) are among weavers employed in garment industries. It also seeks to assess the working postures of machine weavers using the Rapid Upper Limb Assessment (RULA) tool, in order to identify ergonomic risks and suggest possible improvements in their workplace conditions.

METHODS

A cross-sectional study was carried out in selected garment industries across the Kolkata region between April 1 and April 30, 2024. A total of 122 weavers took part in the research. Workers who were eighteen years old or more and had employed in the garment industry for at least one year and had no pre-existing musculoskeletal, neurological, or chronic physiological conditions unrelated to occupational exposure were included in the study. Workers aged below eighteen years, those employed for less than one year, individuals with a history of recent traumatic injury or musculoskeletal surgery, pregnant women, and those who declined to provide written informed consent were excluded from the study. The participants were divided into two groups based on their years of work experience: Group A, comprising workers with less than 12 years of experience, and Group B, consisting of those with more than 12 years of experience. The participants were randomly selected to minimize selection bias and ensure a representative sample of the workforce.

After obtaining written consent, participants were interviewed using a structured questionnaire to collect information on their background, socioeconomic status, work history, and health habits. The Nordic Musculoskeletal Questionnaire (NMQ) was used to identify musculoskeletal problems, while the Rapid Upper Limb Assessment (RULA) tool assessed posture and physical strain. Data were analysed using SPSS version 19, with descriptive statistics summarizing key variables. The chi-square test and odds ratios (OR) with 95% confidence intervals (CI) were used to examine relationships between work factors and musculoskeletal disorders, considering $p<0.05$ and $p<0.001$ as significant.

The study protocol was granted ethical approval by the Institutional Ethics Committee, and prior permission was obtained from the management authorities of the selected cotton garment units before data collection was initiated. Written informed consent was obtained from all participants before data collection, and all assessments were conducted by trained investigators in accordance with ethical guidelines.

RESULTS

From the collected data, the mean age of the 122 weavers was 33.6±11.77 years (mean±SD). According to the demographic information, approximately 65% of the weavers have been engaged in weaving for more than 12 years. Although the mean weight of the weavers was 61.45±12.79 kg, their average Body Mass Index (BMI) was 23.73±4.62, indicating that nearly all the participants fall within the normal BMI category. The educational background of the weavers was satisfactory, as nearly 95% of them had completed primary education. Among all participants, 66% reported being smokers.

Table 1: Demographic values of weaver.

Characteristics	Percentages (%)
Work experience	
<12 years	40
≥12 years	60
Education	
Illiterate	05
Secondary	95
High-secondary	01

Table 2: Physical problems of weavers.

Characteristics	Percentages (%)
Breathing issues/chest tightness	
<12 years	35
≥12 years	65
Comorbidity: Group A: 24%; Group B: 76%	
Types of comorbidities work personnel	
Diabetes	32
Hypertension	25
Chronic lung disease	33

Table 3: Statistical data of wavers.

Variables	Mean	SD (±)	Range
Age (years)	33.63	11.77	33.63±11.77
Height (cm)	160.93	6.98	160.93±6.98
Weight (kg)	61.45	12.79	61.45±12.79
BMI (kg/m²)	23.73	4.61	23.73±4.61
Years of experience	12	9.94	12 ± 9.94
Duration of work (hours)	11	2.70	11±2.70
Number of working days in a week	6.89	0.24	6.089±0.24

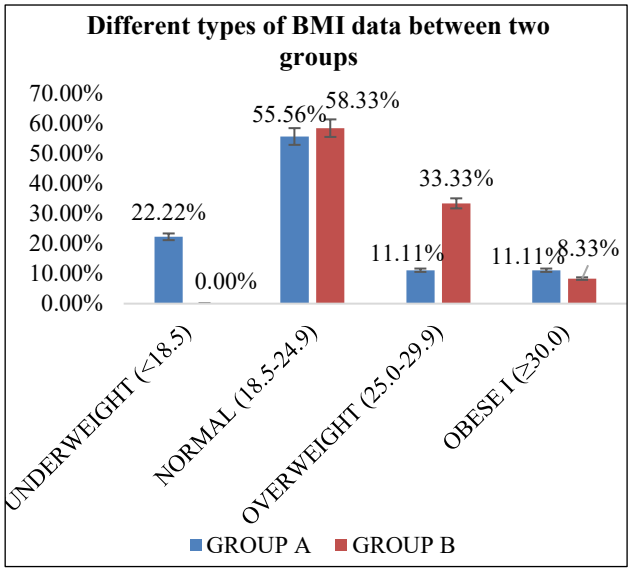
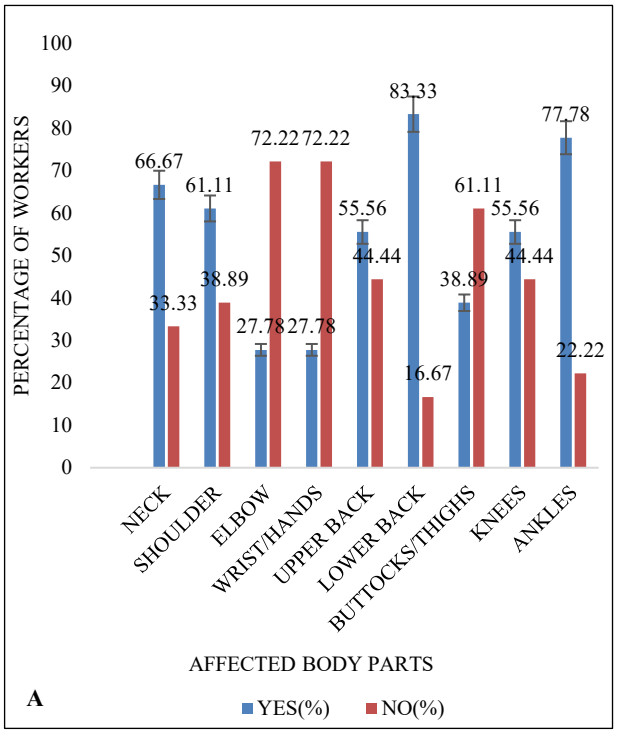


Figure 1: Different types of BMI data shown in a bar diagram.

A simple index known as the Body Mass Index (BMI), calculated from each subject's height and weight, was used to assess their nutritional status and categorize them as underweight, normal, overweight, or obese. When the calculated BMI values were compared with the standardized WHO guidelines, it was found that 55.56% of Group A and 58.33% of Group B belonged to the normal category, while 22.22% of Group A were underweight. Additionally, 11.11% of Group A and 33.33% of Group B were classified as overweight, as depicted in Figure 2, which presents the BMI distribution in a bar diagram.



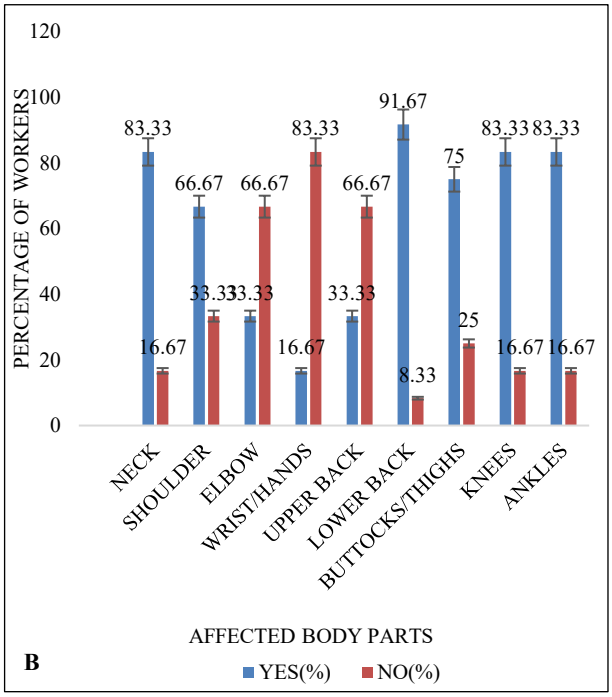


Figure 2: Percentages of felling pain in different body parts (group A) Different types of body part pain percentage for last 12 months from Nordic musculoskeletal disorder questionnaire (group B) Different types of body part pain percentage for last 7 days Nordic.

Among the 122 subjects, 67 reported experiencing musculoskeletal disorders (MSDs) in one or more body

parts within the last 12 months. The overall prevalence of MSDs among machine workers was found to be 70%. When analysed by specific body regions, in Group A, the highest prevalence of MSDs was observed in the neck (66.67%), while in Group B, it was 83.33%. Following this, the upper back showed a prevalence of 55.56% in Group A and 33.33% in Group B. The other body parts also reported of having pain: shoulders group A 61.11%, group B 66.67%; elbows - group A 27.78%, group B 33.33%; wrists or hands - group A 27.78%, group B 16.67%; lower back-group A 83.33%, group B 91.67%; thighs group A 38.89%, group B 75%; knees - group A 55.56%, group B 83.33%; and ankles or feet - group A 77.78%, group B 83.33%. The study showed that age, work experience, work duration, sit characteristics was higher among participants who complained of having MSDs.

In the last seven days, the group A has felt extreme pain in the neck (55.56%), shoulder (55.56%), elbow (33.33%), lower back (83.33%), knees (55.56%), and ankles (77.78%). They suffered more pain in the knee, ankle, and neck areas. About 38% of the symptomatic garment workers had pain in Buttock's side.

For Group B, the soft cotton garment machine workers also felt pain in different body parts. They also experienced extreme pain in other body parts, like the neck (83.33%), shoulder (66.67%), elbow (33.33%), wrist (16.67%), upper back (33.33%), and lower back (91.67%).

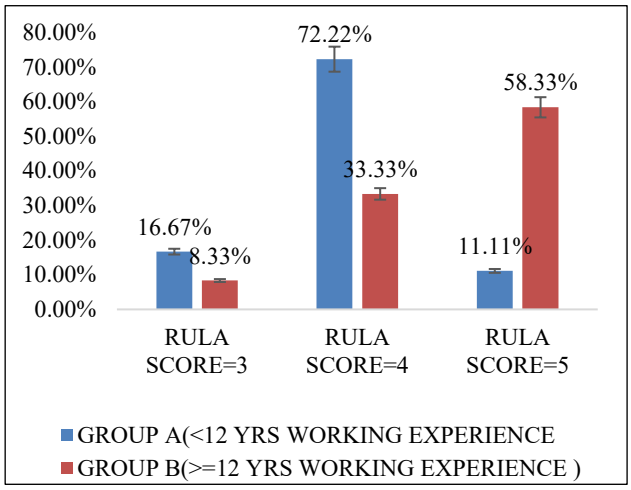


Figure 3: RULA score percentage value for two groups.

Figure 3 illustrates the RULA scores of weavers with less than 12 years of experience (Group A) and those with more than 12 years of experience (Group B). Among Group A, approximately 72.22% of machine operators have a RULA score of 4, indicating a low-risk level, while 16.67% have a RULA score of 3, which is also considered low risk. About 11.11% of machine operators experience body pain, corresponding to a RULA score of 5, and this group tends to suffer more due to their younger age. The RULA score reflects the degree of musculoskeletal disorder (MSD) risk associated with a specific job task. It enables the assessment of postural strain on a worker's upper limbs and helps identify the muscular effort involved in maintaining a working posture. Based on these findings, it can be inferred that the weavers are at a significant risk of injury due to their working posture, resulting in a high prevalence of shoulder and neck pain. For group B, consisting of individuals with more than 12 years of experience, higher RULA scores were observed. About 33.33% of machine operators have a RULA score of 4, suggesting low-risk jobs, whereas 8.33% have a RULA score of 3, also categorized as low risk. However, 58.33% of machine operators report physical pain, corresponding to a RULA score of 5. The RULA score indicates the level of MSD risk that must be addressed for the occupational task under evaluation. It is used to assess postural stress on the upper limbs and determine the muscular effort required to maintain a specific working posture. From these observations, it can be concluded that the work posture of weavers poses an unacceptable risk of injury, leading to a high incidence of shoulder and neck pain.

Table 4 presents the results of univariate and multiple logistic regression analyses of the variables associated with musculoskeletal disorders (MSDs) in different body parts. The multiple logistic regression indicates that the occurrence of musculoskeletal symptoms in various body regions was significantly associated with both individual factors - such as age, gender, body mass index (BMI), and engagement in regular sports and physical activities - as well as occupational factors, including the work experience as an operator, work duration per day, the duration of continuous work without a break, work pressure, and working postures (assessed using the RULA method). However, factors such as working speed, job satisfaction, the use of adjustable chairs, operators' satisfaction with table and sewing machine design, educational level, and smoking habits did not show a significant correlation with the reported symptoms. Less than 12 years' experience - 44.44% of people are smokers and 55.56% are non-smokers. Greater than 12 years' experience - 66.67% of people are smokers, and 33.33% of people are non-smokers.

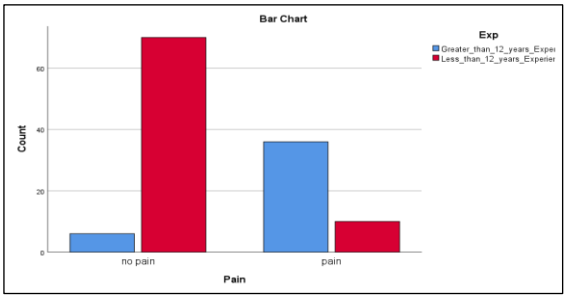


Figure 4: Chi-Square test of two groups (no pain) and (pain) (p≤0.05).

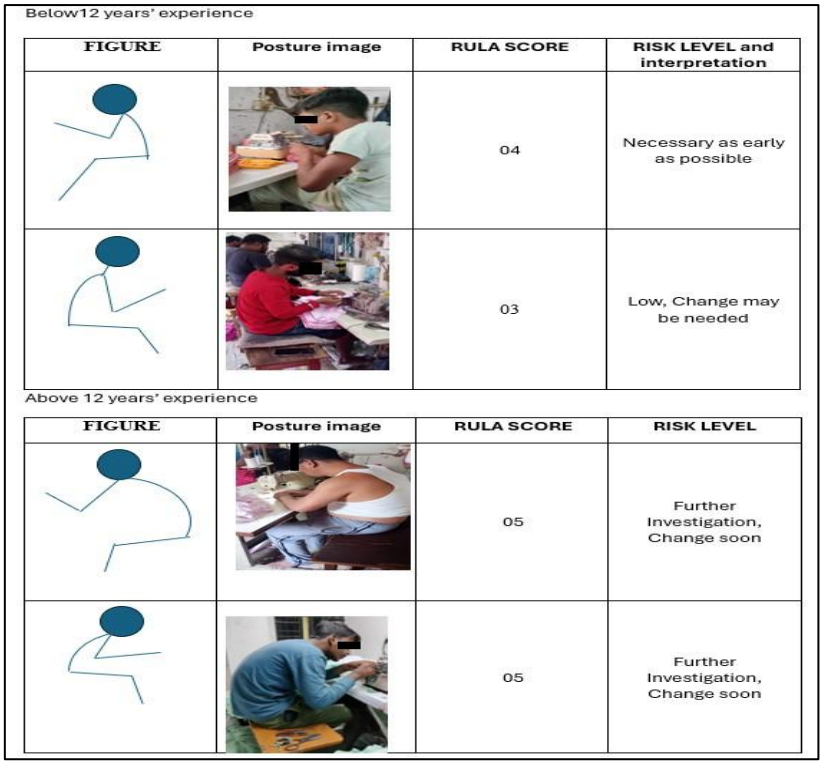


Figure 5: Stick diagrams and images of weavers (<12 years and >12 years' experience) with RULA scores and action categories.

Table 4: Univariate and multiple logistic regression analyses of factors associated with upper back and lower back symptoms (statistically significant values are shown in bold).

Variables	Upper back symptoms (Univariate)			Upper back symptoms (Multivariate)			Lower back symptoms (Univariate)			Lower back symptoms (Multivariate)		
	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
Gender: Male	11.4	5.75-20.5	0.001	10.9	5.1-18.2	0.001	1.27	0.39-2.53	0.467	-	-	-
Age (per year)	1.02	0.99-1.04	0.096	-	-	-	1.02	0.98-1.06	0.181	-	-	-
BMI	0.88	0.82-0.94	0.001	-	-	-	1.05	0.97-1.14	0.186	-	-	-
Smoking (Yes vs. No)	6.06	2.93-12.5	0.001	-	-	-	1.38	0.57-3.31	0.471	-	-	-
Work experience (years)	1.08	1.04-1.11	0.001	-	-	-	1.01	0.97-1.05	0.444	-	-	-
Daily working hours	2.93	2.19-3.93	0.001	1.71	1.21–2.43	0.002	1.06	1.03-1.12	0.019	1.04	1.01-1.09	0.028
Work pressure (Yes vs. No)	2.35	1.78-3.23	0.003	1.89	1.55-2.99	0.006	1.52	0.57-4.05	0.398	-	-	-
Job satisfaction (Low vs. High)	0.27	0.16-0.47	0.001	-	-	-	0.9	0.46-1.76	0.776	-	-	-
RULA grand score (≥5 vs. ≤4)	1.26	1.09-1.20	0.035	1.29	1.12-1.27	0.032	1.67	1.18-2.41	0.002	1.56	1.14-2.50	0.004

Table 5: Symmetric measures, significant table. (p≤0.05).

Chi-Square tests					
	Value	**df**	**Asymptotic Significance (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	62.852[a]	1	0.000	-	-
Continuity Correction	59.774	1	0.000	-	-
Likelihood ratio	66.942	1	0.000	-	-
Fisher's exact test	-	-	-	0.000	0.000
Number of valid cases	122	-	-	-	-
[a]0 cells (0.0%) have an expected count less than 5. The minimum expected count is 15.84.					

DISCUSSION

Work-related musculoskeletal disorders (MSDs) were found to be a common issue among workers in the garment industry, especially among sewing machine operators in the study area. This observation is in line with findings from countries such as Sweden, Denmark, the UK, Finland, and Boston, where between 34% and 75% of workers reported experiencing pain in the neck and shoulder regions. Interestingly, a study from Los Angeles, USA, showed comparatively lower figures, with 25% of workers reporting neck pain and 16% reporting shoulder pain.[21]

When we compared the Body Mass Index (BMI) of participants with the World Health Organization's (WHO, 2004) standard guidelines (as shown in Table 3), we found that most workers - 55.56% in group A and 58.33% in group B - had a normal BMI. However, 22.22% of group A were underweight, while 10% fell into the overweight category. These results suggest that nutritional status and dietary habits might play a role in the workers' overall health and could be linked to the musculoskeletal problems observed which is similar as Ghorai et al.[22]

Previous research by Banerjee et al, Kolgiri & Hiremath, and Bogin et al also supports this idea, showing that body growth patterns often change depending on the type of work a person does.[23-25] This suggests that the physical demands of one's occupation can shape not only posture and muscle use but also overall body composition over time.

The relation between BMI and their abnormal body health from their food habits and their related work. The majority of the subjects in our study had shoulder, back, and wrist pain, which could be due to the repetitive nature of the job and the poor design of the spinning wheel. Similar findings had been reported by Punnelt et al and Kolgiri et al in female garment workers.[26,27]

The overall prevalence of occurrence of MSDs among weavers is 85%. But by body parts, the highest prevalence rate of MSDs is seen in the neck, 66.67% (group A) and 83.33% (group B). Here, more experienced workers feel more pain in their neck position.

In case of lower back pain, people with less than 12 years of experience (83.33%) suffer slightly less than those with above 12 years of experience among soft cotton machine workers. This is a significant support to our study. Grandjean has reported that sitting posture has a disadvantage because it affects digestion and breathing due to prolonged slacking of the abdominal musculature and the purported ill effect of the flexion of the lumbar spine. Since the women in our study were involved in two jobs, spinning and farm work, as a means of income to support their family, and also being married, had family responsibilities and household work, which could be a major factor for their residual musculoskeletal pain. As there are residual pain and fatigue, productivity slows down. This compels workers to speed up the work, increasing symptoms and setting up a vicious cycle. The remedy is rest, which is bypassed in the process of reaching the target. For the spinning, handwork is cyclic, and both the agonists and the antagonists get some rest through the inhibition of the impulses.

For the past seven days, Group A has experienced severe discomfort in the neck (55.56%), shoulder (55.56%), elbow (33.33%), lower back (83.33%), knees (55.56%), and ankles (77.78%). They are more prone to pain in the knee, ankle, and neck areas. Approximately 38% of symptomatic garment workers experienced buttock pain.

In the Group B category, soft cotton garment machine workers reported pain in different body areas. Other body areas such as the neck (83.33%), shoulder (66.67%), elbow (33.33%), wrist (16.67%), upper back (33.33%), buttock/thighs (75%), and knee (83.33%) had severe pain.

From RULA score Table 5, it states that people with 12 years of experience, the RULA score exceeds their action category. About 70% weavers are severally affected as per their RULA score evaluation.

Among 60 subjects, more than 58.33% of workers are at a high-risk level among those who have worked for above 12 years in this sector (Group B). Also, for group A garment weavers, below 12 years of experience, most of

the workers are comparatively at a low-risk level, where the RULA score is 4 (72.22%).

The RULA score represents the level of MSD risk for the job task being evaluated. It is to allow the analysis of postural stresses on a worker's upper limbs and to identify the muscular effort associated with a working posture. From here we can assess that the weaver's posture is too risky for injury from their work posture. So, the Weavers have a high prevalence of shoulder and neck pain. So, immediately change their posture to prevent their pain. Gheysvandi, Elham in their study stated a high prevalence of shoulder and neck pain due to their sitting postures.[28]

In this sector, many workers have limited educational opportunities, which often means they lack proper awareness about nutrition and the needs of their own bodies. As a result, many also develop unhealthy lifestyle habits that further affect their overall health and well-being. The present study revealed that the garment industry employs more workers in the productive age group (18-58 years) and shows a growing trend of more women joining the garment industry, which is comparable with a study by Saha et al in Kolkata.[29] Despite the availability of technically advanced tools, this labour-intensive sector plays a major role in employing people from the lower socio-economic classes. The majority of the participants (65.8%) in our study were employed in sections that involved prolonged hours of sitting. These results are comparable with a study done by Tiwari et al, where 60.7% of the study subjects adopted a standing posture during the majority of their working hours.[30] They were advised to take a rest in between long periods of work to reduce postural strain.

The study showed that age, work experience, work duration, and sitting characteristics were higher among participants who complained of having MSDs. From the modified Nordic questionnaire result, we assess that the weavers' musculoskeletal symptoms in ergonomic or occupational health are at risk. Many of the weavers reported experiencing pain and discomfort, most commonly due to maintaining a seated posture for long periods without adequate support or movement breaks. This prolonged sitting posture places continuous strain on the muscles and joints, leading to the development of MSDs over time. Among those experiencing musculoskeletal disorders, the most from Santu et al paper states that the implementation of ergonomic design into weaver workstations minimizes the adverse effects of their current working postures and improves the weavers' work posture and their quality of life.[31]

With an odds ratio of 11.4 for men, the results of multiple logistic regression models showed that experience-related gender was a significant factor for upper back complaints when it came to individual risk variables. This could be explained by the fact that men and women have different work habits (for example, those with more than 12 years of experience worked more hours in a day). Age and upper back pain in sewing workers have been found to be significantly correlated in two previous research.[32,33] Age was substantially positively correlated with knee complaints in our study. Gaining a deeper understanding of the specific demands of each task can guide the development of future job designs that are more accommodating to older workers, helping them remain healthy, productive, and comfortable in their roles.[34] Additionally, compared to other workers, operators who participated in sports had a lower likelihood of reporting hand or wrist pain. Similar findings in a paper in a Dutch working population, this study also found a strong positive correlation between Body Mass Index (BMI) and knee-related complaints.[35]

These results emphasize that future research on musculoskeletal complaints in this working population should take individual characteristics (e.g., age, gender, and BMI) and regular physical activities into account.

The results of this study have a number of ramifications. Given the importance of Small and Medium Enterprises (SMEs) to economic growth, better working conditions in this industry might have a big influence on both the national economy and the standard of living for employees. The results further emphasize how important workplace prevention is in lowering MSDs. These results highlight the significance of sewing duties in relation to musculoskeletal problems, both individually and professionally. Based on workers' anthropometry, ergonomic practice may involve improving the design of the sewing workstation (e.g., reducing bad working postures). In order to help prevent such symptoms in this working group, several specialized interventions that attempt to improve work organization - such as limiting the number of hours worked per shift or week and providing enough rest breaks are also advised.

This study has few limitations. The study precluded the establishment of causal relationships between occupational exposure and musculoskeletal disorders. This cotton garment units present in the Kolkata region, and the use of self-reported questionnaire data may have limited the generalizability of the findings.

CONCLUSION

The necessity for ergonomic interventions to improve the working conditions of this working group is highlighted by the high prevalence of musculoskeletal pain and discomfort among sewing machine operators, especially in the neck, shoulders, upper back, lower back, and hands/wrists. The study's comparatively high RULA scores point to a poorly designed sewing workstation indicating that, in the majority of cases, the operators' workstation postures need to be examined and that some adjustments are urgently needed. Musculoskeletal symptoms affecting different parts of the body were closely tied to how the work was structured. Long working hours, extended periods of sitting without

adequate breaks, and spending many years in the same role all contributed to the workers' discomfort. Many also described feeling constant pressure to meet production targets, which not only heightened their mental stress but also intensified the physical strain they experienced during work. In order to decrease the frequency and intensity of complaints, it is also advised to restrict the number of hours worked in a single shift or week, limit the number of hours worked without interruption, and provide sufficient rest periods.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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