

# Ergonomic Design Prediction Model for Power-Loom Industry

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## Abstract:

Detecting a worker's health scenario has been shown to be affected by musculoskeletal disorders (MSDs) and other health risks via visual perception. Five hundred and forty samples were collected throughout the selected power loom industry and participated by completing survey forms, videos of regular tasks, and work-related risks which affect job satisfaction, efficiency, and productivity. The ergonomic design predictive model (EDPM) has been evaluated to reduce the probability of MSDs and found that the said factors are fundamental risks to society and their families. Unlike much of the existing literature, EDPM carries out exploratory and confirmatory factor analysis to reveal health risks as work-related physical disorders in the power loom industry. REBA/RULA and Nordic musculoskeletal questionnaires' have taken care of the efficiency of EDPM and model implementation via MATLAB software. Given that the results are focused on reducing the pain score of workers and modifying the working environment through the change of floor height with the provision of hand rest as a sample in the threading department.

**Keywords:** Ergonomic design predictive model, MATLAB, REBA/RULA, Power-loom industry.

## 1. Introduction

The employees of the power loom industry differ in their nature of work at the workplace in that they believe that the MSDs examined are usual, uncomfortable health conditions associated with locomotor devices. Such parts as tendons, ligaments, muscles, cartilage, skeleton, nerves, and vascular system are subject to the pain score and associated upper limb. Musculoskeletal disabilities have become prevalent as a main group [1]. It should be noted that musculoskeletal disabilities account for 40% of the costs associated with work-related injuries and illnesses. Because of poor occupational health care or a failure to assess workplace risk factors and conditions, such disorders progress or worsen [2]. Research has shown that work and Musculoskeletal disorders resulting from static and repetitive work rise to compelled and unchanged body postures, sustained repetitive motion, and compressed forces on the neck, lower back, knee, shoulder, arm, hand, and wrist without sufficient recovery between the movements. Even though the power loom industry became one of the prime industries in Maharashtra, contracting innumerable workers in manufacturing activities face loss of efficiency and productivity due to the acceptance of the WMSD stimulus by developed countries and acknowledge the necessity to put an end to this suffering and losses, as said earlier about the productivity issues of the power loom industry [3,4]. According to the International Ergonomics Association (IEA), an ergonomist can help activities, products, environments, and systems be consistent with people's demands, capabilities, and limits.

Knowledge of ergonomic principles and ergonomic interferences of the power loom industry may influence WMSDs prevention and management. Said industries involve the combination of repeated movements that lead to various kinds of muscular, ophthalmological, and orthopedic issues, which then proceed to WMSDs among workers who maintain poor postures. It should be noted that there are consistent limitations in interpreting the results of studies measuring the imbalance between workplace demands and workers' physical skills to prevent WMSDs; assessing hazards that generate a range of distress on muscles, nerves, and joints, particularly in the upper extremity and lower back; and categorizing technology and tools in such a way that a large hazard is eliminated. elements related to WMSDs whereby classification of risks is represented through questionnaires, experimental technologies, direct estimations, or observational techniques. There are likely different direct estimation techniques called Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) indices, which depend on observations of biomechanical position and postural. In these studies [5-7] procedures were potentially adapted to furnish displays which attain WMSDs, particularly above body parts such as the neck, stalk, and overlying limbs.

Videotaping is a conventional procedure in ergonomics as it allows splitting a work period into several periodic cyclic elements, referred to as subtasks [8]. The period spent during each of these subtasks can likewise be deduced as a work cycle level [9]. Observational methods have been realized on videotape using specific software [10-11], despite this, the process is typically time-consuming. The achievable observational techniques were practically possible for extensive use in several professional environments, but the scoring technique was debased as a consequence of the absence of epidemiological information [12]. MSD issues were evaluated using the Nordic Musculoskeletal Symptoms Questionnaire (NMSQ) developed by Ref [13], in addition to the Portuguese version produced by Ref [14], and variations developed by Ref [15]. Researchers [16–18] largely use the NMSQ to evaluate MSD. The NMSQ was fundamentally categorized into three for the various regions if they had three sub-measures. When respondents perceived musculoskeletal difficulties that had been reported for a week, they were instructed to reply to the first sub-measures (NMSQ1 to NMSQ9) [19]. This paper aims to improve the working atmosphere of the power loom industry by offering the knowledge and value of ergonomic principles to enhance their physical condition by embracing the ergonomic factor as a vital consideration to maintain the worker's post-MSDs. This sustainable, ergonomic prediction model will be used on personal and environmental variables to test incorrect postures using a sigmoid predictive function and regressive equations.

## **2. Materials & methods**

There were 540 workers from major departments of the power loom industry as participants who completed the study, with an average age range of 21–60 ( $\text{Age} = 32.24 \pm 4.03$ ) from Solapur city. Every participant completed a consent form prior to participating in the study. The information was gathered from recorded video clips, images, and completed questionnaires' forms in order to identify body sections exaggerated by MSDs using ergonomic risk assessment RULA, REBA, and NMSQ, which analyze statistics over collected data using SPSS software. A logistic regression model was performed to determine

the sigmoid predictive function analysis and implement the quantified effects of personal and work environment factors using MATLAB software.

### 2.1 Rapid upper limb assessment (RULA)

By the method of RULA [20] directly measured grades of musculoskeletal burdens on activities, whereas people have an injury to their upper extremity and neck burden. It has done the evaluation of body position, force, and action connected with stationary activities of employees. Such activities encompass computer or monitor-dependent jobs, production, or commercial activities wherein operators are standing or sedentary with no movement around. As an illustration of the activity, the apparatus offers a score that measures the body position, exertion, and motion needed. Such scores are assembled into three activity grades in such a way that they contribute a sign of the duration, after which it is realistic to anticipate hazardous management to begin. RULA has been generated with the need for minimum training as described and stated that employees unskilled in human engineering might precisely evaluate upper extremity discomforts [21]. From an operational standpoint, Ref [22] emphasized the importance of RULA, which evaluates an operator's body position and their relative hazard grade in less time with just paper and pen and is unframed in contributing described positional details, namely the position of fingers, which may be pertinent to the operator's general hazard. In other words, it is essential to compare other evaluation apparatuses based on an in-depth or well-described ergonomic examination and utilized to evaluate a specific activity or body position for an applier or several appliers. Two contributions to RULA are furnished from recorded videos or photos of employees who are performing activities. First, it helps the contrast between the present and intended job station designs based on a rationale or recommendation for ergonomic modifications. Second, RULA scores pay to some non-ergonomists or stakeholders with proof that intended changes can decrease musculoskeletal burdening. For the RULA task, participants were subjected to evaluating body posture followed by a sequence of two steps to note down the score and complete the work sheet, clarified as follows:

- **Step-1**-As the body positions for evaluation are chosen, a RULA assessment describes an instant in the task period, and it is significant to observe the body positions used during the completion, work period, or a substantial operating cycle earlier to choose the body positions for assessment. The choice could be the longest-held body positions or what appears to be the worst body positions chosen based on the type of examination.
- **Step-2**-The scores of body positions are marked by utilizing a sheet that comprises a diagrammatic representation of body parts and tables. Resolve which body parts are in danger and their requirements to be evaluated. The scoring paper must be followed to measure the scores for several body part positions labelled as Group A and B. As a final point, Table C must be utilized to measure the total score.
- **Step-3**-Derived scores are transformed into one of the three activity grades, which pointers weigh in on the total score. Generally, to assure those in effectual control of some dangers, they detect the activities directly from detailed examination.

The sequence of steps to prepare the score sheet for RULA displayed in Figure 1. Systematically, it combines the upper arm, lower arm, wrist, and wrist twist scores by means of Table A, and then muscle and exertion scores are summed up to make score C. The calculated score of the neck, trunk, and legs from Table B, added with muscle, proceeds to the final score of D by summation of exertion score. Finally, scores C and D were utilized to find the total score with the help of Table C. The complete worksheet of RULA is wide-open in Appendix I.

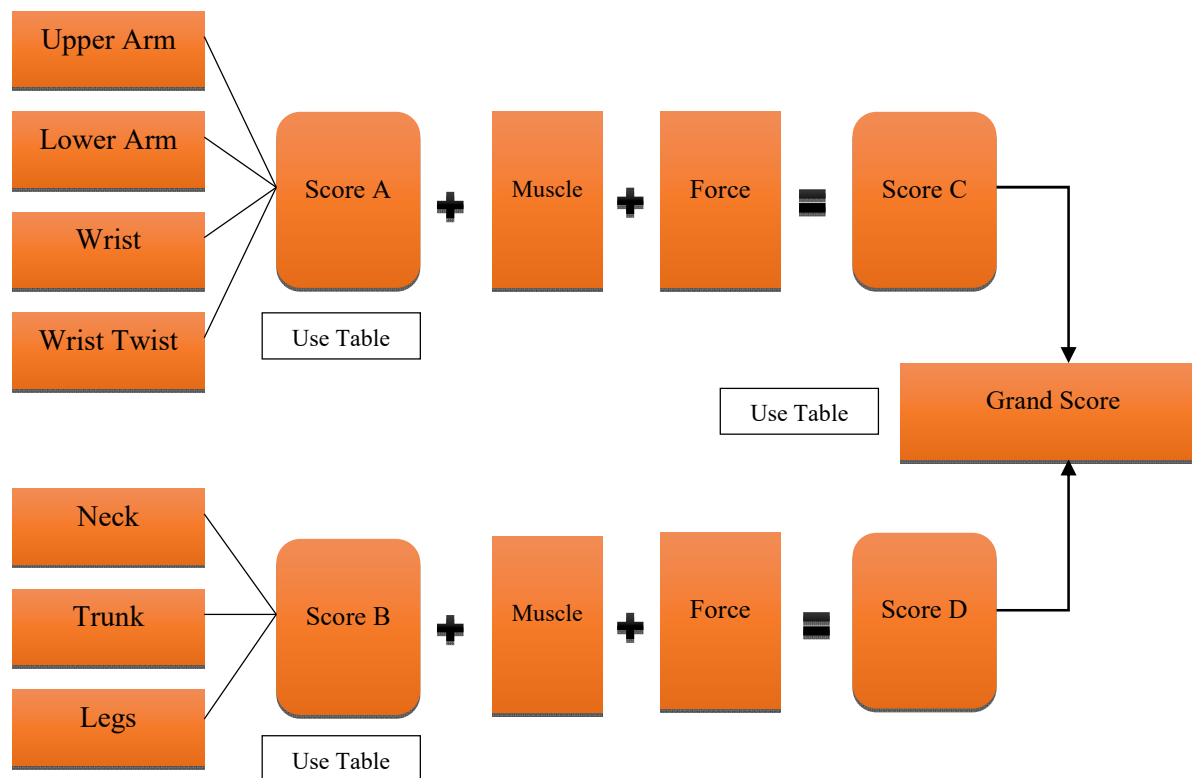


Figure 1 Scoring sheet of RULA

Table 1 provides a description of each action level range with its risk grade. Three action levels are presented with the sketch of the lower level consists of a score range of 1-2, the medium level has a medium risk and consists of RULA score 3-6, while the high risk stays when the RULA score is 7.

Table 1 RULA Action level

| RULA Action Level      |                               |                 |
|------------------------|-------------------------------|-----------------|
| The span of RULA score | Description                   | RULA risk grade |
| 1-2                    | The job is of almost safe     | Low             |
| 3-6                    | The job is of reasonably safe | Medium          |
| 7                      | The job is of highly risky    | High            |

## 2.2 Rapid entire body assessment (REBA)

In the need of essential assessment [23] developed to look into dynamic work where there is a possibility of WMSDs named REBA, which are used to look at things that RULA

wasn't built for. REBA is based on the RULA posture score measures and is designed to track risks related to knee postures, loads or forces applied, coupling, and whole-body activities. [23]. As mentioned by Ref [24] REBA was created to satisfy a noticed demand for field apparatus for the practitioner, explicitly framed to be susceptible to the kind of uncertain operating positions observed in health care and other service sectors. Data on body posture, exertions, type of actions, recurrence, and union were collected to conclude the REBA score, which produces a recommendation of the hazard grade and imperativeness whereby activity must be performed. The availability of diverse body posture study apparatuses, REBA subject to interposed between the elaborate activity-evoked mechanisms and time-evoked apparatus, it was created to be utilized as an activity-evoked apparatus because of the data complexity while gathering. The starting position of the body pose is the operational, structurally harmless position. Suppose the body position sways away from the harmless posture, the chance of injury is high [25-26]. Charts were available to change the 144 body position arrangements into one score that depicts the grade of musculoskeletal danger, as shown in Appendix II. These scores were later grouped into three activity grades that suggest the imperativeness of eliminating or decreasing the danger of the evaluated body positions. For the REBA task, participants were subjected to noticing the activity followed by a sequence of five steps to note down the score sheet from postures. Score handling and score setup was described as follows:

- **Step 1-**Notice the activity to construct a typical ergonomic job place evaluation, assessment, and the job's impact on the location sketch and surroundings, the equipment's usability, and the operator's behavior in relation to the adventure risk. As it could occur, subsequently store the data by utilizing photos or video. Yet, with certain operational apparatus tooling, multiple views were suggested to manage errors.
- **Step 2-**Pick which body position to study for the examinations in step one, using the following standards in such a way that several repetitive body positions and prolonged body positions are maintained. Even though the resolution is formulated over numerous standards, the aforementioned standards resolve which body positions can be examined and stated with the outcomes and suggestions.
- **Step 3-**As displayed in Figure 2, the procedure to find the scoring sheet of REBA, the body positions were evaluated utilizing the score paper and body region score paper to find the action level with its risk factors from Table 2. The scoring begins with marking groups: legs, trunk, and neck as Group A and upper extremities as Group B. Group B body positions remain scored distinctively from the left to right portions, as per score paper. The load and exertion scores, the union score, and the action score were allotted at this level, as clarified in Appendix II.
- **Step 4-**Use Table A of Figure 2 to produce a unique score out of the trunk, neck, and leg scores. It was noted in the provisional space on the score paper and summed to the load or exertion score to contribute a score of A. The extremity scores were utilized to produce an individual score utilizing Table B of Figure 2 which was subsequently summed to the union score to generate a B score. The A and B scores were inscribed into the table labelled C in Figure 2, and this solitary score is run through as score C.

- **Step -5-**The kind of muscular action being acted is subsequently signified with an action score, as clearly shown in Appendix II, summed to produce the REBA score. As shown in Table 2, the final span of REBA score is prime risk levels and low risk stays when the RULA score started at 1. The medium level lied within the score range of 2-7, while the high risk stayed within the range of RULA score of 8-15.

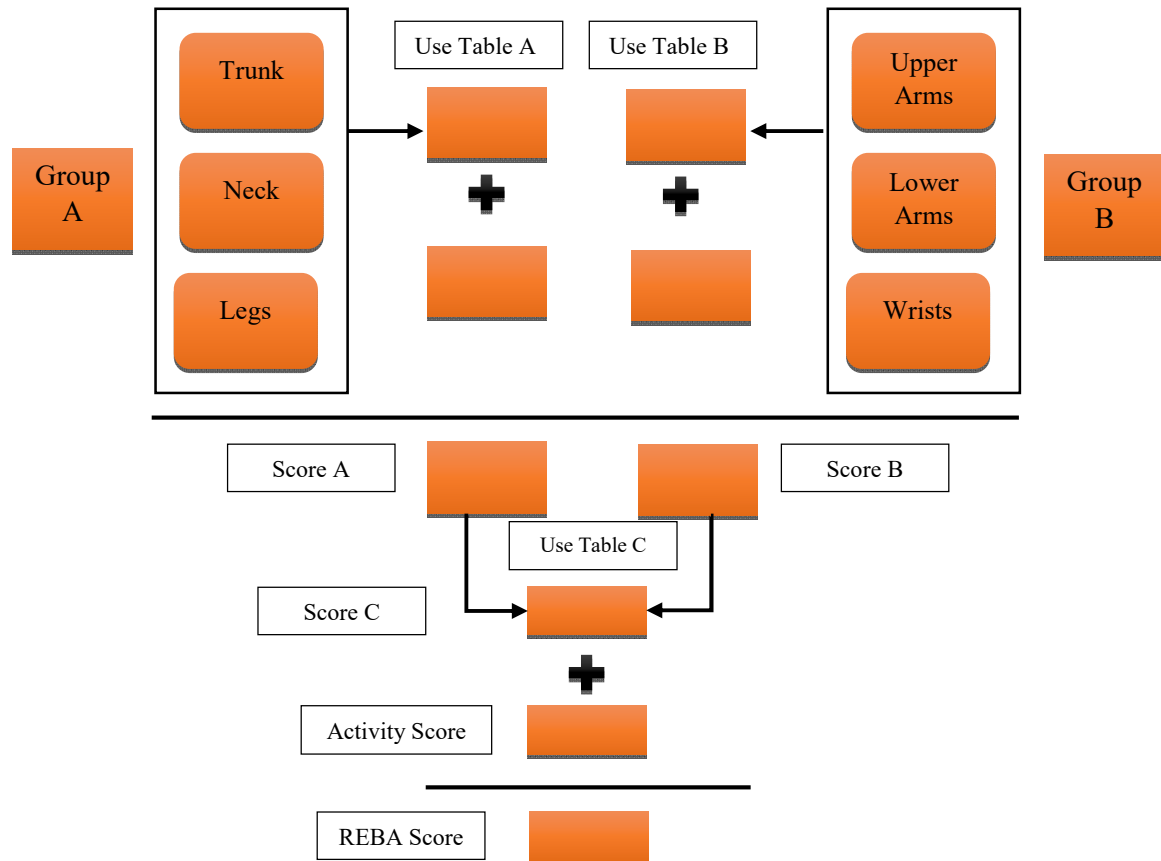


Figure 2 Scoring sheet of REBA

Table 2 REBA Action level

| REBA Action Level      |                               |                 |
|------------------------|-------------------------------|-----------------|
| The span of REBA score | Description                   | REBA risk grade |
| 1-2                    | The job is of almost safe     | Low             |
| 3-6                    | The job is of reasonably safe | Medium          |
| 7                      | The job is of highly risky    | High            |

### 2.3 Logistic regression model

Usually, the relationship between a categorical dependent variable and a group of independent explanatory factors is investigated using logistic regression analysis with the concept of utilizing two values of the dependent variable, such as 0 and 1 or Yes and No. Many of the fundamental assumptions of linear regression models based on the ordinary least squares method, such as the linearity of the relationship between the dependent and independent variables; normality of the error distribution; homoscedasticity of the errors; and

measurement level of the independent variables, were not required in logistic regression [27].

Because of the nonlinear log transformation of the linear regression equation, logistic regression can handle nonlinear interactions between the dependent and independent variables. For each level of the independent variables, the variance of errors can be heteroscedastic. As for independent variables, logistic regression may handle both continuous and discrete data. However, some other assumptions still apply [27-28], as

- I. In logistic regression, the dependent variable must be discrete, preferably dichotomous.
- II. Because logistic regression calculates the probability of an event occurring ( $P(Y=1)$ ), the dependent variable must be correctly coded.
- III. The model should not be under- or over-fitted by including useless variables
- IV. Each observation should be self-contained, with little or no multicollinearity
- V. The log odds of an occurrence are linearly connected to the independent variables
- VI. Because maximum likelihood estimates are less robust than conventional least squares which are used to estimate the unknown parameters in a linear regression model

Logistic regression requires a large sample size. This general-purpose curve fitting procedure is preprogrammed to fit over forty different mathematical models, including linear-growth models and approximate models such as regular polynomials, piecewise polynomials, and polynomial ratios, in addition to the models that unique features of these routines start to fit curves to multiple batches of data instantaneously. Next to that, it uses graphical and numerical tests to compare fitted models across groups, comprising an approximation F-test for curve coincidence and a computer-intensive randomization test to compare curve coincidence and individual parameter values. Finally, the most up-to-date computer-intensive bootstrapping technique to generate bootstrap confidence intervals for parameter values, predicted means, and forecast values is used. The following differential equation represents this model

$$\frac{dN}{dt} = rN(1 - \frac{N}{K}) \quad (1)$$

Integrating, we get

$$N(t) = \frac{K}{1 + (\frac{K}{N_0} - 1)e^{-rt}} \quad (2)$$

$$F(x) = \frac{a}{(1 + e^{bx+c})} \quad (3)$$

## 2.4 Development of a Graphical User Interface for the Prediction Models

Using MATLAB, we developed a graphical user interface for the prediction models. Figure 3 displays the study of the power-loom industry's threading department workstation concerning WMSD. Figure 3 (a) depicts the input GUI window of the developed model where it is required to enter the data of age, department, gender, experience, height, and weight from collecting samples. By clicking the 'Evaluate WMSDs' push button, the

prediction score will be displayed for pain over the different parts shown in the window: body, joints, knees, elbows, lower arms, chest, right shoulder, right arm, leg, and hip. Once you click on the 'Evaluate WMSDs' button, the pain scores immediately appear. The illustration is depicted in Figure 3 (b).

Figure 3 shows two graphical user interfaces for evaluating WMSDs. Interface (a) is the initial state with empty input fields. Interface (b) shows the results after entering details for a user.

**Interface (a) Before the entry of the details for WMSDs:**

Age:  Department:  Gender:  Experience:  Height:  Weight:

BMI:

**WMSD SCORE**

| WMSD                | SCORE |
|---------------------|-------|
| Body                | B     |
| Joint Pain          | J     |
| Knee Pain           | K     |
| Elbow Pain          | EL    |
| Lower Arm Pain      | LA    |
| Chest Pain          | C     |
| Right Shoulder Pain | RS    |
| Right Arm Pain      | RA    |
| Leg Pain            | LG    |
| Hip Pain            | HP    |

**Interface (b) After entering the details for WMSDs:**

Age: 42 Department: threading Gender: male Experience: 12 Height: 172 Weight: 78

BMI: 28.3658

**WMSD SCORE**

| WMSD                | SCORE     |
|---------------------|-----------|
| Body                | No pain 2 |
| Joint Pain          | Worst 9   |
| Knee Pain           | Worst 9   |
| Elbow Pain          | Worst 9   |
| Lower Arm Pain      | Worst 9   |
| Chest Pain          | Worst 9   |
| Right Shoulder Pain | Worst 9   |
| Right Arm Pain      | No pain 2 |
| Leg Pain            | Worst 9   |
| Hip Pain            | Worst 9   |

Figure 3 Graphical user interfaces to evaluate WMSDs (a) Before the entry of the details for WMSDs, (b) After entering the details for WMSDs

### 3. Results & Discussion

#### 3.1 Nordic Musculoskeletal Questionnaires (NMQs)

NMQs were used to assess job performance in assessing body discomfort and have become a systematized examining instrument for determining the body portions affected by musculoskeletal symptoms. They are relatively inexpensive and simple to use without any technical equipment. The data collected from the participants was analyzed using SPSS software, with NMQ scores for females from various departments in the power-loom sector and risk factor ranges listed in Table 3 according to the RULA and REBA. The percentage of operators' reported distress in various regions of the body in these tasks is depicted in Figures 4 and 5.

Table 3: Risk groups adapted to contrast the outcome scores from 2 techniques for evaluating MSD

| Tool | Low Risk | Medium Risk | High Risk |
|------|----------|-------------|-----------|
| RULA | 1-2      | 3-6         | 7         |
| REBA | 1        | 2-7         | 8-15      |

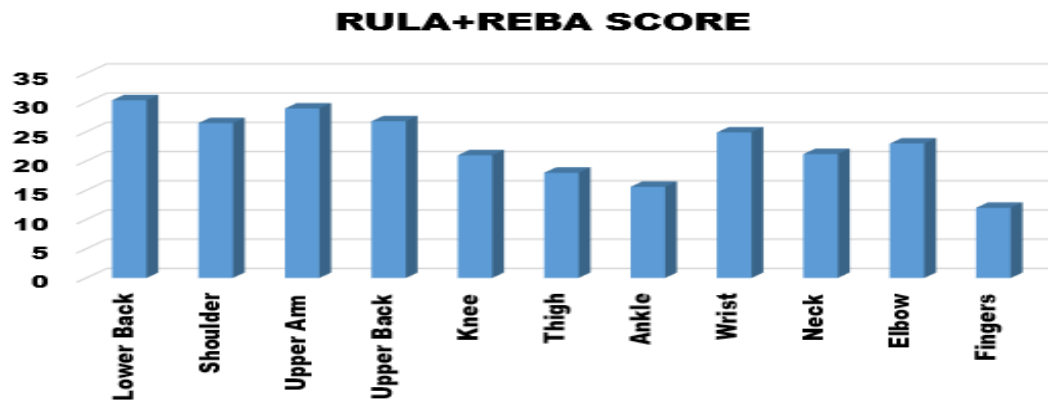


Figure 4 RULA and REBA Score distribution over several body parts

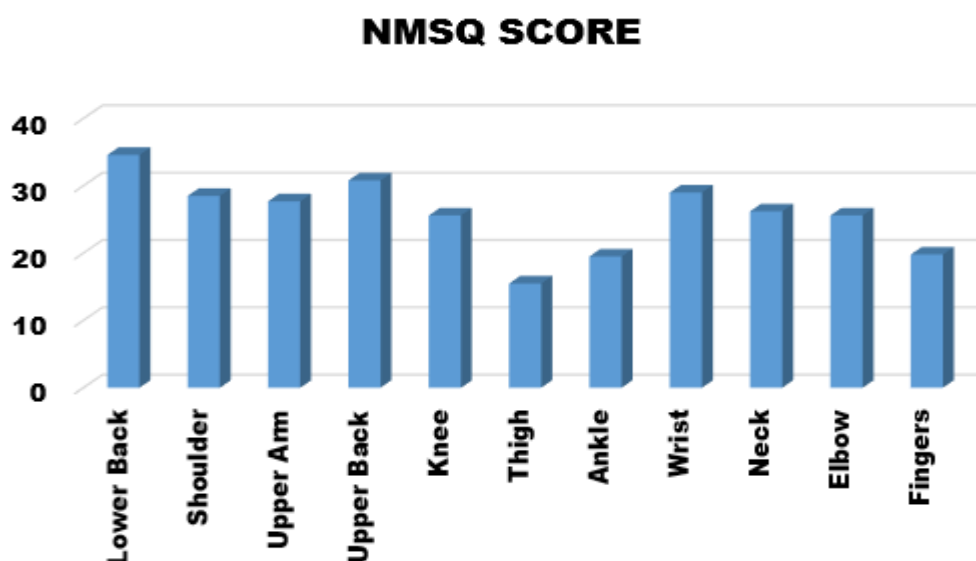


Figure 5 NMSQ Score distribution over several body parts

In the majority of the study, 34.6 percent of respondents reported back pain, while 28.5 percent reported shoulder pain. With a range of 28.6, 27.7, and 30.8 percent, the right wrist and hands, upper arm, and upper back were the second most disturbed sites in the studied population. The findings of this study revealed that in their working conditions, power-loom weavers maintain a persistent forward-flexing body position, which results in an average of 47.23 percent of the population having at least one work-related musculoskeletal pain. Similarly, the study also looked at textile tufting operators who managed thread cones and found that 64.9 percent had at least one job associated with musculoskeletal misery. To ensure our investigation substantially compared with the Ref [29] statement, finalized identically, the majority of the respondents in our examination had shoulder, back, and wrist aches, which could be because of the recurred type of the task and the wrong operating body position. Although an identical effort has been made by Ref [30] associated with body position utilized by goldsmiths in their operating provisions in India, RULA/REBA applied investigation has sought to indicate the operating body position effectively. It was observed that the age of operators of the power-loom industry affects generations of MSDs over physical parts, namely the elbow (25.6%), knee (25.6%), and ankle/feet (19.5%), with

influenced health condition by the neck (26.2%) and thigh (15.5%). As stated in the NMSQ inventory, activity in squatting and standing positions was noticed. The investigation previously depicted the severe effect of activity positions on ankles and feet (23%), and it had a substantial effect on generations of MSD in the neck (42%), elbow (21%), and back (50%). Diffusing distress from the neck and shoulders was substantially observed in the occurrence of MSD in the back, so that body weight and active stress were directed at pain generation in the knee. Therefore, 14% of workers had attended the clinic [31-32].

### 3.2 Fitting equation of BMI for male and female

The graph of  $N(t)$  versus  $t$  is elongated S-shaped and the curve is symmetrical about its point of inflection, as shown in Figure 6. Individuals with a low BMI have a lower risk of developing WMSD than those with a medium BMI ranging between 23 and 27. The WMSD affected individuals with a high, greater than 27 BMI, might have a slightly higher BMI than individuals with a low BMI, as the high BMI population has become higher than the low BMI population recently. Normal BMI populations affected by WMSD are the more significant and central themes of our study. Figure 7.a further illustrates that WMSDs affected populations with more experience (greater than 5 years) are higher than WMSDs affected populations with less experience (less than 5 years) under the same BMI categories. Figure 7.b illustrates the logistic regression of BMI of male workers.

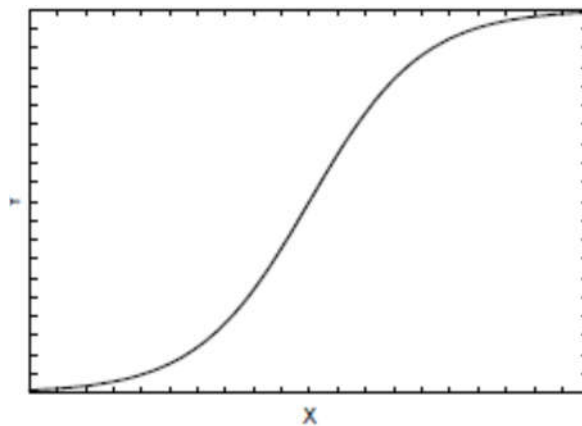


Figure 6 Logistic Regression Model  $F(x) = \frac{a}{(1+e^{bx+c})}$

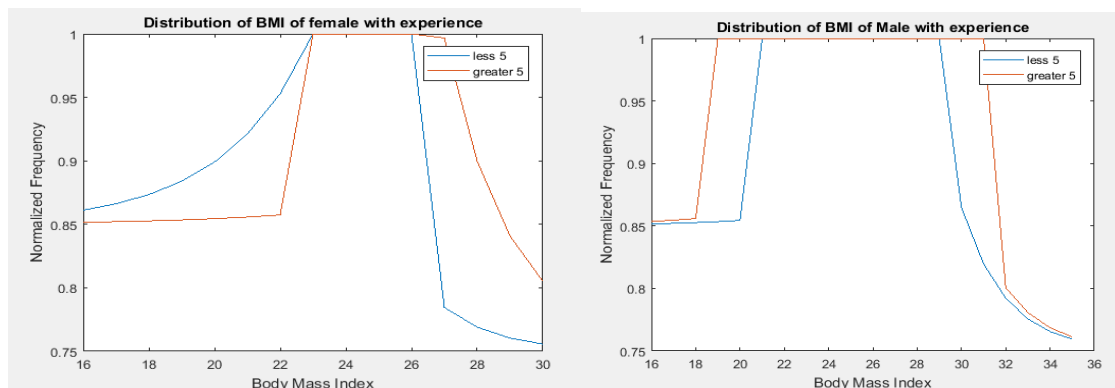


Figure 7 Combined logistic regression model for BMI of (a) female workers (b) Male worker

The probability of WMSD-affected individuals is less than 20 for low BMI compared to a medium range value of between 20 and 32 BMI. The WMSD affected individuals with a high, greater than 32 BMI, which might be slightly higher than those with a low BMI. Therefore, the high BMI population is higher than the low BMI population. Normal BMI populations affected by WMSD are more significant and central themes of our study. Figure 3. (a) further demonstrates that the WMSD affected population with more experience, greater than 5 years, is higher than the WMSD affected population with less experience, less than 5 years under the same BMI categories. Figure 8 indicated that the predicted numbers of individuals affected by WMSD using regression and actual data collected from the WMSD survey and confirmed that the regression model remains the best fit for WMSD affected individuals with low and medium values, less than 27 BMI, and the prediction for high BMI stands a little over the actual data collected, with a mean of 1.87 and SD 0.993 [33].

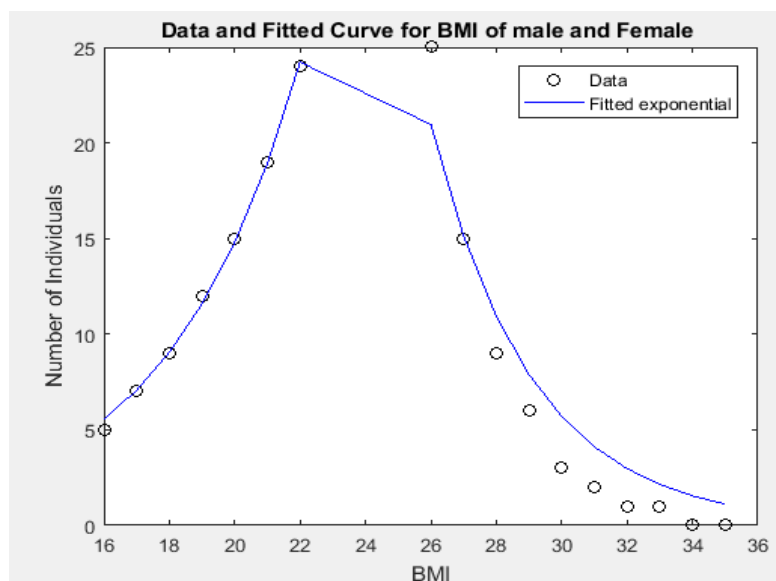


Figure 8 Curve fitting of BMI distribution of male and female workers fitting equations of age and experience of the male and female

Figure 9 (a) and (b) depict the WMSD occurrence and actual prediction from the regression model and actual collected data due to experience and age in both genders who belong to the threading department, respectively. From both the figures, it is inferred that WMSD occurrence increases in sigmoid as with age in both the conditions predicted by the regression model and actual collected data. Figure 10 demonstrated the probability of the occurrence of WMSD over different body parts in workers with increasing inexperience. The sigmoid describes the relationship between the occurrence of WMSD and increasing experience stopovers.

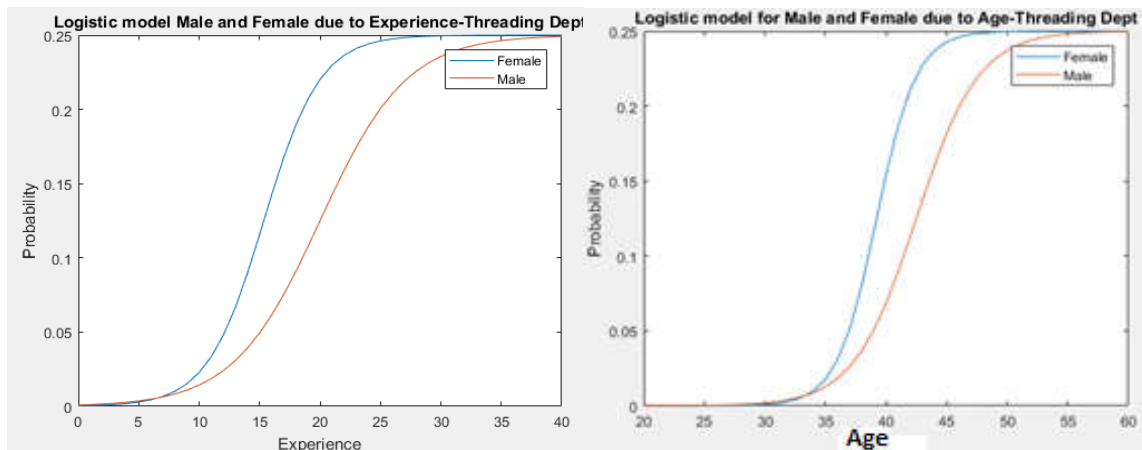


Figure 9 Logistic models for male and female workers due to (a) experience, (b) age-Threading department

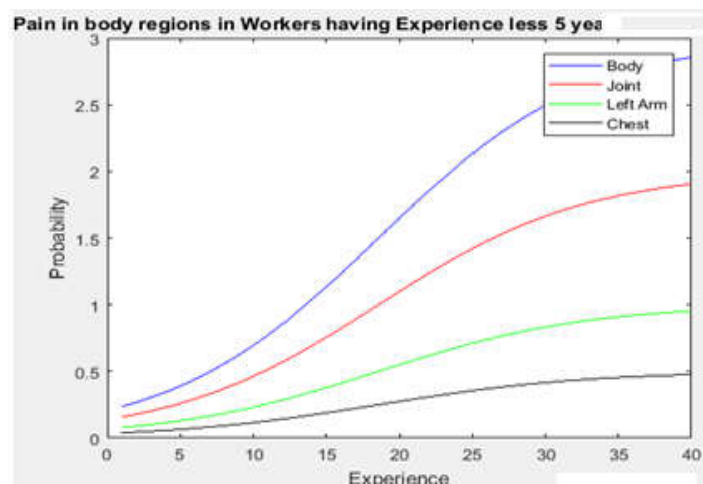


Figure 10 Logistic model for male and female due to experience

Table 4 illustrates some of the abbreviated notations for different body parts used in the following tables and texts. Tables 5 and 6 indicate that a, b, and c are coefficients of the pain logistic regression model of different body parts for male and female workers across several departments under different experience categories. The coefficient 'an' in the table, which is given by four different values (e.g., 3/2/1/0.5), is because in the column 'The values of different pain regions', the value 3 is meant for Body (B), 2 is meant for Joint (J), 1 is meant for Chest (C), Right Shoulder (RS), Right Arm (RA), Left Arm (LA), and 0.5 is meant for Elbow (E), Leg (L), Hip (H) and Knee (K).

Table 4 Chart of abbreviated and body part

| Abbreviated | Body Part | Abbreviated | Body Part      |
|-------------|-----------|-------------|----------------|
| B           | Body      | E           | Elbow          |
| J           | Joint     | RA          | Right Arm      |
| LA          | Left Arm  | RS          | Right Shoulder |
| K           | Knee      | L           | Leg            |
| C           | Chest     | H           | Hip            |

Table 5 Logistic model of pain in body regions with experience of male workers of various depts.

| Department | Gender | Exp.   | b     | c   | a                 | The values of different pain regions |
|------------|--------|--------|-------|-----|-------------------|--------------------------------------|
| Threading  | Male   | Less5  | -0.14 | 2.6 | 3/2/1/0.25        | B/J/ C=RS=RA=LA/E=L=H=K              |
|            |        | Great5 | -0.14 | 2.6 | 0.15/0.025        | B/J=K=E=LA=RS=L=H/B=RA               |
| Spinning   | Male   | Less5  | -0.14 | 2.6 | 3/2/1/0.5         | B/J/ E=LA=C=H=K/RA=L=RS              |
|            |        | Great5 | -0.14 | 2.6 | 0.05/0.083/0.0005 | B/ J=B/E=LA=RS=H=K/RA=C              |
| Weaving    | Male   | Less5  | -0.14 | 2.6 | 3/2/0.1           | B/J=B/LA=K/C=RS=RA=L=H=E             |
|            |        | Great5 | -0.14 | 2.6 | 0.05/0.0415       | B/K=C=B/E=LA=RS=RA=L=H=J             |
| Knitting   | Male   | Less5  | -0.14 | 2.6 | 3/2/0.07          | B/E=C=J/LA=RS=RA=L=H=K               |
|            |        | Great5 | -0.14 | 2.6 | 0.04/0.0415/0.97  | H/J=K=B/LA=C=RS=RA=L=E               |
| Bleaching  | Male   | Less5  | -0.14 | 2.6 | 3/2/0.0625        | B/K=E=L=H=J/C=RS=RA=LA               |
|            |        | Great5 | -0.14 | 2.6 | 0.025/0.075       | J=K=RS=RA=B/LA=C=L=H=E               |
| Dyeing     | Male   | Less5  | -0.14 | 2.6 | 3/2/1/2.5         | B/H/E=LA=K/C=RS=RA=L=J               |
|            |        | Great5 | -0.14 | 2.6 | 0.25/0.1          | H=B/K=E=LA=C=RS=RA=L=J               |
| Printing   | Male   | Less5  | -0.14 | 2.6 | 3/1/0.0625/2      | B=J/E=LA=K/RA=L=C/H=RS               |
|            |        | Great5 | -0.14 | 2.6 | 0.08              | B=J=K=E=LA=C=RS=RA=L=H               |
| Finishing  | Male   | Less5  | -0.14 | 2.6 | 4/3/0.04/2        | B/E=J/C=K/RS=RA=L=H=LA               |
|            |        | Great5 | -0.14 | 2.6 | 0.0625            | B=J=K=E=LA=C=RS=RA=L=H               |

Table 6 shows that for female workers across the threading department,  $a=1.6$ ,  $b=-0.14$ , and  $c=2.6$  coefficient values are used in Equation No. 3 to represent the logistic model for body pain;  $a=1.2$ ,  $b=-0.14$ , and  $c=2.6$  coefficient values are used in Equation No. 3 to represent the logistic model for knee pain;  $a=0.05$ ,  $b=-0.14$ , and  $c=2.6$  coefficient values are used in Equation No. 3 to represent the logistic model for joint pain; and  $a=0.8$ ,  $b=-0.14$  and  $c=2.6$  values of the coefficients are used in Equation no. 3 to represent the logistic model for chest pain. The rest of the elbow pain, leg pain, and hip pain follow the same knee pain model. The right shoulder and right arm continue the same logistic model as the chest.

Table 6 Logistic model of pain in body regions with experience of female workers of various depts.

| Department | Gender | Expel  | b     | c   | a                 | The values of different pain regions |
|------------|--------|--------|-------|-----|-------------------|--------------------------------------|
| Threading  | Female | Less5  | -0.14 | 2.6 | 1.6/1.2/0.05/0.8  | B/ K=E=L=H/J=LA/C=RS=RA              |
|            |        | Great5 | -0.14 | 2.6 | 0.1/0.125         | B=RS/J=K=E=RA=LA=C=L=H               |
| Spinning   | Female | Less5  | -0.14 | 2.6 | 2.8/2.2/1.8/0.05  | B/J /RA=L=RS/ E=LA=C=H=K             |
|            |        | Great5 | -0.14 | 2.6 | 0.1/0.0664/0.0136 | J=B/E=LA=RS=L=H=K/RA=C               |
| Weaving    | Female | Less5  | -0.14 | 2.6 | 3/2/0.1           | J=B/LA=K/C=RS=RA=L=H=E               |
|            |        | Great5 | -0.14 | 2.6 | 0.15/0.0581       | K=C=B/E=LA=RA=RS=L=H=J               |
| Knitting   | Female | Less5  | -0.14 | 2.6 | 3.6/2/0.5         | B/ E=C=J/LA=RS=RA=L=H=K              |
|            |        | Great5 | -0.14 | 2.6 | 0.21/0.0415/0.085 | H/J=K=B/C=RS=RA=L=E                  |
| Bleaching  | Female | Less5  | -0.14 | 2.6 | 2/1/0.0625        | B/ K=E=L=H=J/C=RS=RA=LA              |
|            |        | Great5 | -0.14 | 2.6 | 0.18/0.075        | J=K=RS=RA=B/LA=C=L=H=E               |
| Dyeing     | Female | Less5  | -0.14 | 2.6 | 3/2/0.0625/2.5    | B/ H/E=LA=K/C=RS=RA=L=J              |
|            |        | Great5 | -0.14 | 2.6 | 0.225/0.1         | H=B /K=E=LA=C=RS=RA=L=J              |
| Printing   | Female | Less5  | -0.14 | 2.6 | 3/1/0.0625/2      | J=B/E=LA=K/RA=L=C/H=RS               |
|            |        | Great5 | -0.14 | 2.6 | 0.0625            | B=J=K=E=LA=C=RS=RA=L=H               |
| Finishing  | Female | Less5  | -0.14 | 2.6 | 3/2/0.04/1.8      | B/ E=J/C=K/RS=RA=L=H=LA              |
|            |        | Great5 | -0.14 | 2.6 | 0.0625            | B=J=K=E=LA=C=RS=RA=L=H               |

#### 4. Conclusion

From the above study, it has been concluded that the present investigation of a participant's age indicated an essential correlation of positive value with musculoskeletal signs and musculoskeletal disorders. Musculoskeletal disorders were near to the intermediate stage among workers in the overweight and obese categories. The neck pose has been found to be a significant contributing factor in the occurrence of musculoskeletal signs in the neck and trunk position compared with a significant contributing factor for musculoskeletal signs in the shoulder, upper and lower extremities, back, and the whole trunk. The logistic regression model was computed to comprehend the effect of variables under study on the perceived level of musculoskeletal symptoms experienced by workers in manufacturing activities in the power-loom industry. The design goal of the prediction model of WMSDs is to control and prevent the identified risk factors causing MSDs among workers working in manufacturing units of the power-loom industry. According to the prediction model results, industries can integrate appropriate provisions into the workplace to prevent musculoskeletal disorders using the age and anthropometry of workers. As a result of changes made to the workplace environment, such as raising the floor height and installing hand rests, as an example in the threading department, the pain scores for various body parts, including the neck, left arm, back, elbow, right arm, right shoulder, leg, and hip, significantly improved. The neck, back, and elbow scores improved even more significantly.

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