Ergonomic Study in Domestic Sewing Machine

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1 Introduction

A sewing machine was used to join two pieces of cloth with the help of a thread. In the first industrial revolution to decrease manual sewing work, mechanical sewing machines were introduced by Englishman Thomas Saint in 1790. Mechanical sewing machines are single stitch type sewing machines. The increasing population leads to the development of sewing machines in order of garments growth. Still, the mechanical sewing machine is being used in the domestic sector because of its low cost, it stands as the backbone of the economically backward peoples (Fig. 1).

The nature of the operation is in such a way that, the operator is working with forwarding moved body posture, tilting head, bent trunk, and static sitting posture. During work, the sewer has to simultaneously move hands, arms side by operating the foot pedal continuously. The awkward posture of the lower extremities, upper extremities, and repetitive movements result in a higher prevalence of musculoskeletal complaints. NASA Task Load Index (NASA-TLX) questionnaire, which was a simple technique to identify perceived physical and mental workload, was used as a basic tool for the start of the study. Sealetsa and Thatcher [1] using a spinning cone and cushion can reduce MSD. The armrest on the chair reduces the ergonomic problem [2]. Scientifically designed sewing workstations reduce muscular-skeletal diseases [3]. Every part of the sewing operation is ergonomically designed to reduce work-related musculoskeletal disorder [4]. The designing workstation according to operator anthropometric value [5]. An ergonomic design chair [6] controls the forward bend position. Armrests on sewing machines [7] support arms. Field test on a sewing

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Fig. 1 Awkward postures

machine by risk assessment and design ergonomically [8]. Providing ergonomics can increase productivity. It reduces fatigue [9]. Forcing people on different tasks and environments reduces productivity [10]. The ergonomic risk factors are contributing to musculoskeletal disorder [11].

In this many research papers were reviewed and from which we got to know variously ergonomically study techniques which had been done at the industrial level to reduce occupational health hazard but not at the domestic level.

2   Materials and Methods

2.1   Theoretical Background

Ergonomics study is done in order to study human capabilities in relationship to work demands.

Classification of Ergonomics
The ergonomics are broadly classified into three categories they are:

1. **Physical Ergonomics**:
   Physical activities related to anatomical, anthropometric, and physiological factors [12].
2. **Cognitive Ergonomics**:
   Mental workload like decision-making, skilled performance, and work stress factors [12].
3. **Organizational Ergonomics**:
   Communication, resource management, and design of working times [12].

Ergonomic Risk Factors
See Table 1.

Table 1 Ergonomic risk factors

Ergonomics factor	Example
Physical hazard	Static muscle load Awkward posture
Psychosocial	Cognitive stress Social relationship Psychological factors Lighting Noise
Organizational factors	Excessive work rates Duration of work Inadequate work break
Individual risk factor	Obesity, BMI, sex
Athletic activities/hobbies	Knitting and sewing Musical instrument

Rapid Entire Body Assessment (REBA)

REBA was the most popular and widely used observational ergonomic tool for postural assessment of jobs both in industrial and service sectors [13]. Different working postures can be measured easily and quickly. No formal ergonomic skill and no training are required to use this tool, only pen and pencil is required. The whole body evaluation in both static and dynamic work can be assessed by REBA.

The worksheet is divided into two sections as

- Section A—trunk, neck, and leg (Table A)
- Section B—upper arm, lower arm, and wrist (Table B)

Initially, find a table a (trunk, neck, and leg) and table B (upper arm, lower arm, and wrist) values. By adding load and coupling value to table A and table B we get Score A and Score B. Finally, from score A and score B, we obtain a score of C and then the activity score is added to get the final REBA score [14] (Fig. 2).

Based on the REBA score, the level of MSD risk was identified. The table shows the level of MSD risk and the required action to be taken (Table 2).
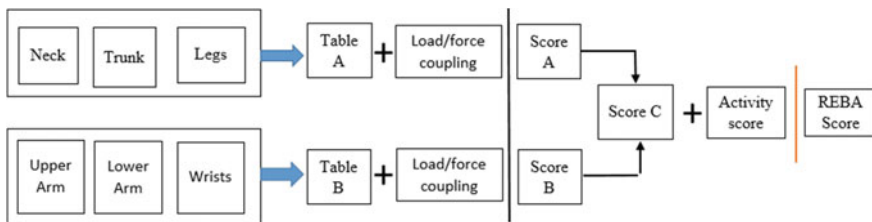
Fig. 2 Flow chart of REBA

Table 2 Risk level chart

Score	Level of MSD risk
1	Negligible risk, no action required
2–3	Low risk, change may be needed
4–7	Medium risk, further investigation, change soon
8–10	High risk, investigate and implement change
11+	Very high risk, implement change

Fig. 3 Methodology

2.2 *Methodology*

See Fig. 3.

2.3 *Evaluation*

Ten different people who use the sewing machine for domestic purposes were taken for the study. The sewing job was divided into three categories based on function. they are.

1. Sitting
2. Threading
3. Tailoring

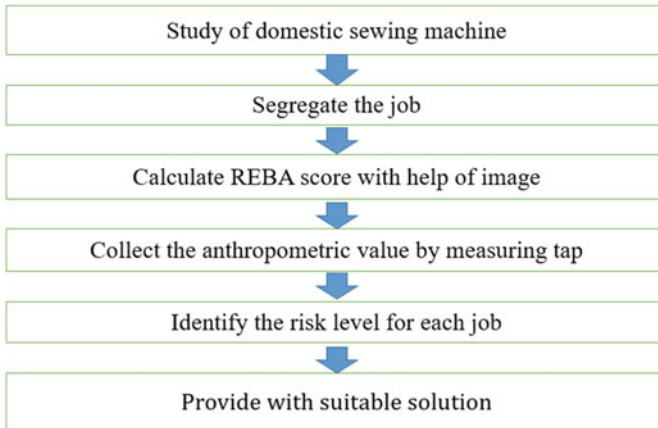Rapid Entire Body Assessment (REBA) was ten people for the job segregated. Thus based on the job segregation, 30 different work postures at different angles were taken into consideration for a total of 10 different persons for this study.

Sitting

Totally ten postures were taken into consideration concerning 10 different people and the REBA score was evaluated.

A person 1 example for REBA calculation of sitting posture (Fig. 4).

Figure 5 shows REBA scoring for sitting posture. The value obtained from table A was 2 which indicates that the trunk value as 1, the neck value as 1 and for legs, its 2. The load/force coupling score as 0 thus the overall score A as 2. The value obtained from table B was 1 which indicates that the upper arm value as 1, lower arm value as 1, and wrist value as 1. The coupling score as 0 thus the overall score B as 2. From score A and score, B obtained the score C value was 1 hence the total REBA score, concerning activity score 0 was 1. The REBA score indicates that the job is done at a negligible risk level hence no action is required.
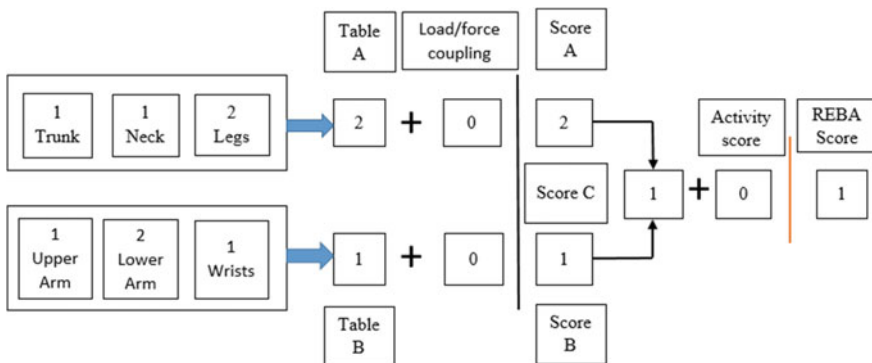

Fig. 4 Example for Sitting Posture

Fig. 5 REBA Score for person 1 sitting

The same procedure was repeated to identify the risk level for sitting posture of other persons also (Tables 3, 4 and 5).

From the study, it was analyzed that the average REBA score obtained for 10 people was 1 which means MSD risk level was a negligible risk and no action is required.

Threading

Totally ten postures were taken into consideration concerning 10 different people and the REBA score was evaluated.

A Sample example for REBA calculation of Threading posture (Fig. 6).

Figure 7 shows REBA scoring for threading posture. The value obtained from table A was 7 which indicates that the trunk value as 4, the neck value as 3 and for legs, its 2. The load/force coupling score as 0 thus the overall score A as 7. The value

Table 3 Score A for sitting

	Neck	Trunk	Leg	Table A	Load	Score A
Person 1	1	1	2	2	0	2
Person 2	1	1	2	2	0	2
Person 3	1	1	2	2	0	2
Person 4	1	1	2	2	0	2
Person 5	1	1	2	2	0	2
Person 6	1	1	2	2	0	2
Person 7	1	1	2	2	0	2
Person 8	1	1	2	2	0	2
Person 9	1	1	2	2	0	2
Person 10	1	1	2	2	0	2

Table 4 Score B for sitting

	Upper arm	Lower arm	Wrist	Table B	Load	Score B
Person 1	1	2	1	1	0	1
Person 2	1	1	1	1	0	1
Person 3	1	1	1	1	0	1
Person 4	1	1	1	1	0	1
Person 5	1	1	1	1	0	1
Person 6	2	2	1	2	0	2
Person 7	1	2	1	1	0	1
Person 8	1	2	1	1	0	1
Person 9	1	2	1	1	0	1
Person 10	1	2	1	1	0	1

Table 5 REBA score for sitting

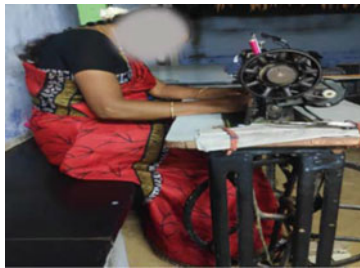|	Score C	Activity	REBA
Person 1	1	0	1
Person 2	1	0	1
Person 3	1	0	1
Person 4	1	0	1
Person 5	1	0	1
Person 6	2	0	2
Person 7	1	0	1
Person 8	1	0	1
Person 9	1	0	1
Person 10	1	0	1

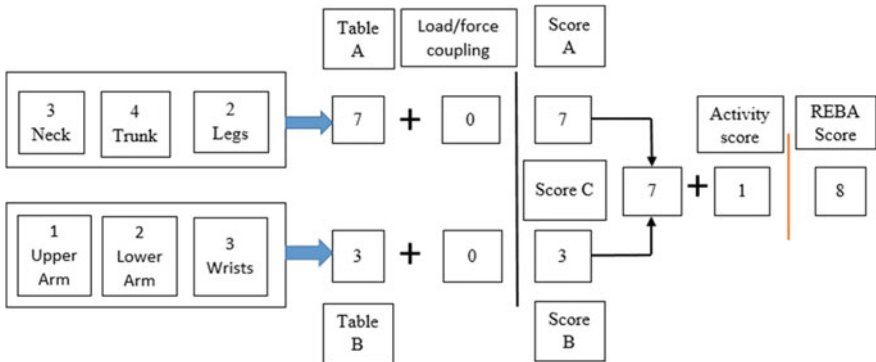**Fig. 6** Example for threading posture

Fig. 7 REBA Score for person 1 Threading

obtained from table B was 3 which indicates that the upper arm value as 1, lower arm value as 2, and wrist value as 3. The load/force coupling score as 0 thus the overall score B as 3. From score A and score B obtained the score C value was 7 hence the

Table 6 Score A for threading

	Neck	Trunk	Leg	Table A	Load	Score A
Person 1	3	4	2	7	0	7
Person 2	3	3	2	6	0	6
Person 3	3	2	2	5	0	5
Person 4	3	3	2	6	0	6
Person 5	3	4	2	7	0	7
Person 6	3	4	2	7	0	7
Person 7	3	4	2	7	0	7
Person 8	3	4	2	7	0	7
Person 9	3	4	2	7	0	7
Person 10	3	4	2	7	0	7

Table 7 Score B for threading

	Upper Arm	Lower Arm	Wrist	Table B	Load	Score B
Person 1	1	2	3	3	0	3
Person 2	2	1	3	3	0	3
Person 3	1	1	3	2	0	2
Person 4	1	2	3	3	0	3
Person 5	2	2	3	4	0	4
Person 6	1	2	3	3	0	3
Person 7	1	2	3	3	0	3
Person 8	1	2	3	3	0	3
Person 9	1	2	3	3	0	3
Person 10	1	2	3	3	0	3

total REBA score, concerning activity score 1 was 8. The REBA score indicates that the job is done at high risk hence implement change immediately.

The same procedure was repeated to identify the risk level for the threading posture of other persons also (Tables 6, 7 and 8).

Table 8 REBA score for threading

	Score C	Activity	REBA
Person 1	7	1	8
Person 2	6	1	7
Person 3	4	1	5
Person 4	6	1	7
Person 5	8	1	9
Person 6	7	1	8
Person 7	7	1	8
Person 8	7	1	8
Person 9	7	1	8
Person 10	7	1	8

From the study, it was analyzed that the average REBA score obtained for 10 people for threading operation was 7.6–8 which means MSD risk level was a high risk, investigation, and implement change is needed immediately. In the threading process, the person was worse in their appearance. Therefore, it has a higher risk of musculoskeletal disorder. In this activity, investigate and implement changes to reduce the risk level of MSD.

Tailoring

Totally ten postures were taken into consideration concerning 10 different people and the REBA score was evaluated.

A Sample example for REBA calculation of tailoring posture (Fig. 8).

Figure 9 shows REBA scoring for tailoring posture. The value obtained from table A was 4 which indicates that the trunk value as 2, the neck value as 2 and for legs, its 2. The load/force coupling score as 0 thus the overall score A as 4. The value obtained from table B was 3 which indicates that the upper arm value as 1, lower arm value as 2, and wrist value as 3. The load/force coupling score as 0 thus the overall score B as 3. From score A and score B obtained the score C value was 4 hence the
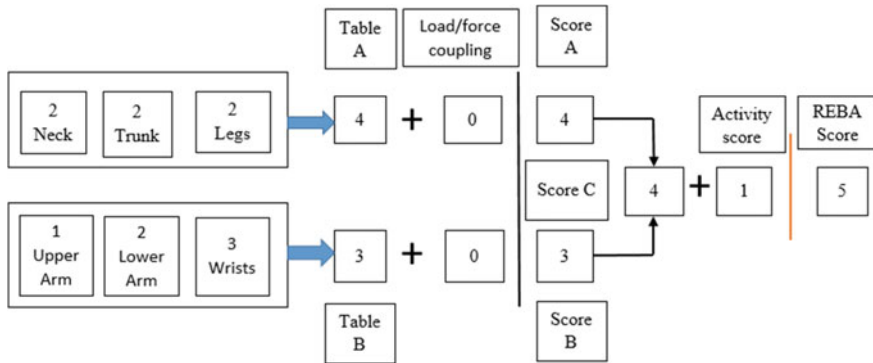

Fig. 8 Example for tailoring posture

Fig. 9 REBA score for sample 1 tailoring

total REBA score, concerning activity score 1 was 5. The REBA score indicates that the job was done at medium risk and further investigation and changes to be bought soon to reduce MSD.

The same procedure was repeated to identify the risk level for tailoring the posture of other persons also (Tables 9, 10 and 11).

From the study, it was analyzed that the average REBA score obtained for 10 people for tailoring operation was 5.2–6 (approximate) which means MSD risk level is medium risk and further investigation and changes to be bought soon to reduce MSD.

Table 9 Score A for tailoring

	Neck	Trunk	Leg	Table A	Load	Score A
Person 1	2	2	2	4	0	4
Person 2	2	1	2	2	0	2
Person 3	2	2	2	4	0	4
Person 4	2	2	2	4	0	4
Person 5	2	3	2	5	0	5
Person 6	2	2	2	4	0	4
Person 7	2	3	2	5	0	5
Person 8	2	3	2	5	0	5
Person 9	2	2	2	4	0	4
Person 10	2	4	2	4	0	4

Table 10 Score B for tailoring

	Upper arm	Lower arm	Wrist	Table B	load	Score B
Person 1	1	2	3	3	0	3
Person 2	1	2	3	3	0	3
Person 3	3	2	3	5	0	5
Person 4	1	2	2	3	0	3
Person 5	1	2	3	3	0	3
Person 6	1	1	3	2	0	2
Person 7	1	2	3	2	0	2
Person 8	2	2	3	4	0	4
Person 9	1	2	3	3	0	3
Person 10	1	2	3	3	0	3

Table 11 REBA score for tailoring

	Score C	Activity	REBA
Person 1	4	1	5
Person 2	2	1	3
Person 3	5	1	6
Person 4	4	1	5
Person 5	4	1	5
Person 6	4	1	5
Person 7	4	1	5
Person 8	5	1	6
Person 9	4	1	5
Person 10	6	1	7

3 Results and Discussions

The study was about analyzing MSD risk level, for a total of 10 persons using the sewing machine for domestic purposes with job segregation as sitting, threading, and tailoring for 30 different postures using the REBA tool. The REBA score obtained for sitting posture for 10 different people was 1 hence the risk level was found negligible. The REBA score obtained for threading posture for 10 different people was 8 hence the risk level was found high. The most affected body part identified was the trunk due to bending while inserting thread in the needle. Thus to reduce the risk level magnifier was kept near the needle in the sewing machine. A sewing machine magnifier makes it easy to insert thread and examine fine details including stitch quality, without bending the trunk, thus reducing stress and strain. Thus finally the risk level would also be reduced (Fig. 10).

Fig. 10 Magnifier

Fig. 11 Adjustable chair
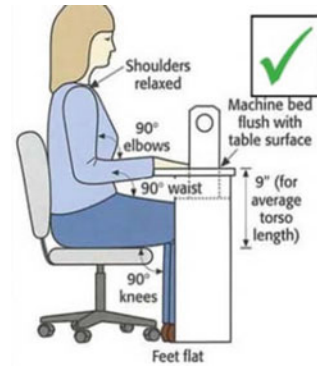
The REBA score obtained for tailoring posture for 10 different people was 6 hence the risk level was found medium. A major job for sewer was tailoring thus further investigation to be done to reduce the medium risk level. The most affected body part was found to be the wrist. Therefore, either the sewing machine or chair should be of the adjustable type, in order to change concerning proper anthropometric values. In this study, the mechanical sewing machine was taken into consideration in which the table cannot be adjustable hence the chair should be of the adjustable type to reduce the risk (Fig. 11).

An adjustable chair was of high cost which cannot be afforded by all domestic sewers hence cushion can be provided to increase height such that the wrist is in proper alignment with the sewing machine.

4   Conclusion

The highlight of this study was to rise ergonomic awareness among the domestic sewer. The study majorly concentrates on economically poverty people. Following the Occupational Health and Safety Administration (OSHA) degree of freedom from risk and hazard in all environments [15], to provide a better working atmosphere for

domestic sewer this study will be a better source on further use to reduce the MSD risk factor of people using the sewing machine. Thus suitable ways to reduce the risk level are,

- Develop good visibility to the needle area.
- To create an easy-to-operate foot pedal mechanism.
- Appropriate adjustable chair to work.
- Maintain space for movement while standing and sitting.
- Special arm supports to be attached.

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