

III METHODOLOGY

Occupational health not only deals with work-related diseases but it also encompasses all factors that affect workers' health. There is an urgent need for strengthening skills, developing newer capacities and broadening knowledge in the area of occupational health. If the efficiency of the currently existing training facilities in India is increased, the prospect of occupational health will obviously improve a great deal. The necessary changes in this area will be based on a coordinated national effort focused on clear national goals and objectives. Possible economic benefits results from prevention programmes must be aced before the management, trade unions and policy makers.

The methodology pertaining to the present study on "Ergonomic Interventions to Promote Occupational Health and Safety among Workers Employed in Garment Industries" comprises of four phases (Figure 1).

- A. Baseline survey of garment workers
- B. Creating awareness on occupational safety and health
- C. Assessment of workplace hazards and medical screening of the workers
- D. Designing and evaluating ergonomic furniture

A. Baseline Survey of Garment Workers

Survey is a method of securing relevant information concerning a phenomenon under study, since it has the advantage of wider scope and accuracy of information (Kaliaperumal and Nagarajan, 2009). A survey was conducted to find out the prevailing environmental conditions in the industries, the awareness of workers on the importance of occupational safety and health and need for ergonomic approach to improve their working environment. This part of the study includes:

1. Selection of area
2. Selection of subjects
3. Selection of method
4. Preparation and finalisation of tool
5. Conduct of the study
6. Consolidation and analysis of data

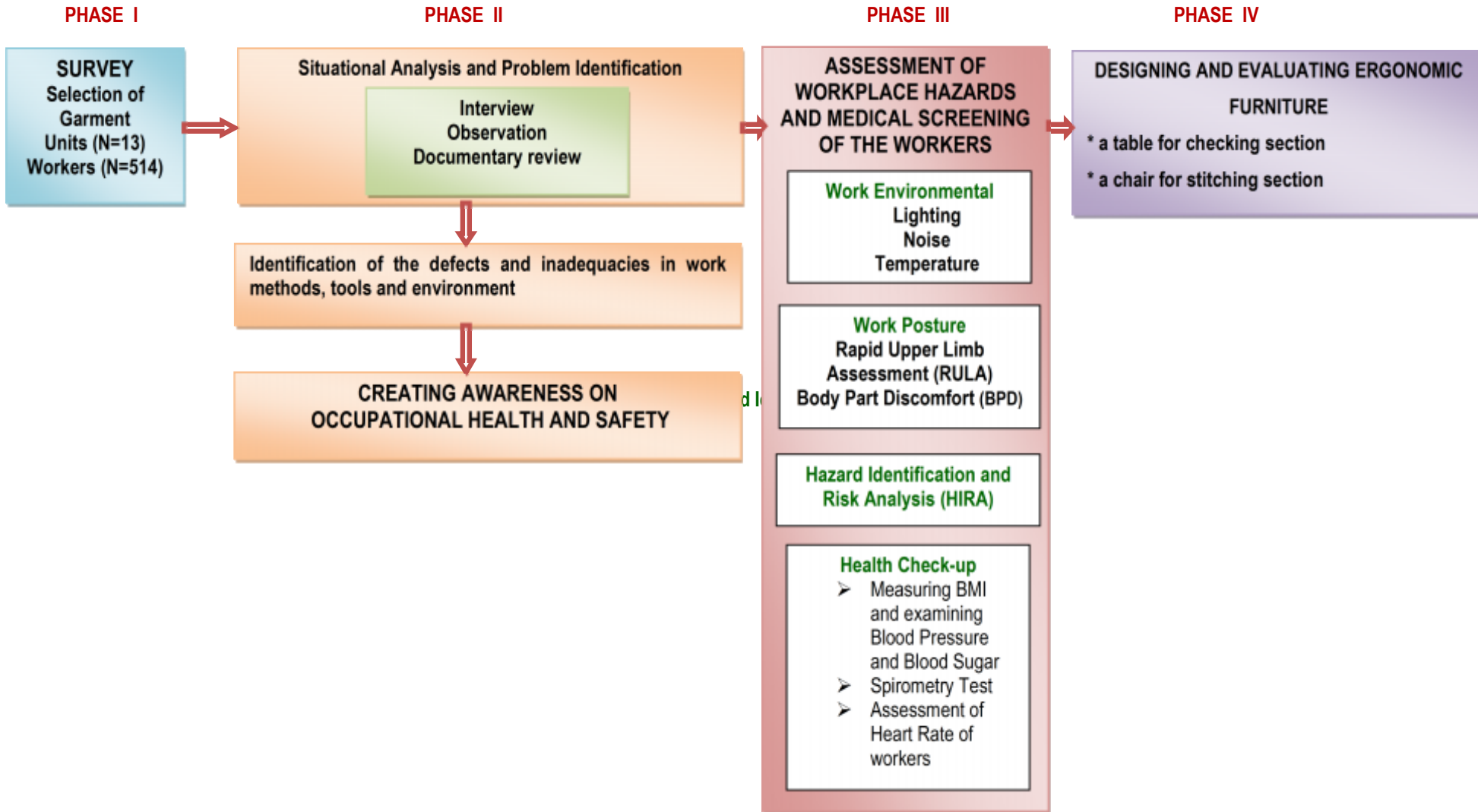


Figure 1: Design of the Study

1. Selection of area

Tirupur was selected to conduct this study because garment production in Tirupur also known as “T-Shirt City” accounts for approximately 80 per cent of India’s total production of knitwear for export (Regional Report, 2010). Tirupur District lies on the western part of Tamil Nadu, India (Figure 2). Tirupur industrial cluster constitutes one of India’s important foreign exchange earners, with a total export value of around Rs.11,000 crore in 2007. It is estimated that there were about 10,000 production units in Tirupur, employing more than 4,00,000 workers, but real numbers might well be higher than this. There were small number of large factories employing 1,000 workers or more per unit, with smaller enterprises employing between 100 and 250 workers just below (Neve, 2008).

2. Selection of subjects

Five hundred and fourteen workers employed in 13 large, medium and small scale garment industries were selected using purposive sampling method. Sampling may be defined as the selection of some part of an aggregate or totality on the basis of which a judgment or inference about the aggregate or totality is made. In other words, it is the process of obtaining information about an entire population by examining only a part of it (Kothari, 2009). According to Thakur (2005) purposive sampling helps in picking up the cases that are considered to be typical of the population in which researcher is interested.

3. Selection of method

Interview cum observation method was selected in order to obtain accurate informations for the present study. According to Ahuja (2003) interview is a two person conversation initiated by the interviewer for the specific purpose of obtaining relevant information and focused by the interviewer on the content specified by the research objectives of description and explanation, while observation is a systematic viewing of a specific phenomenon in its proper setting for the specific purpose of gathering data for a particular study.

According to Saravanavel (2000), interview method is a survey method of data collection. Personal interviewing is an effective, informal, verbal and non-verbal conversation, initiated for specific purpose and focused in certain planned content areas. Since the interviewer goes to the residence of each selected

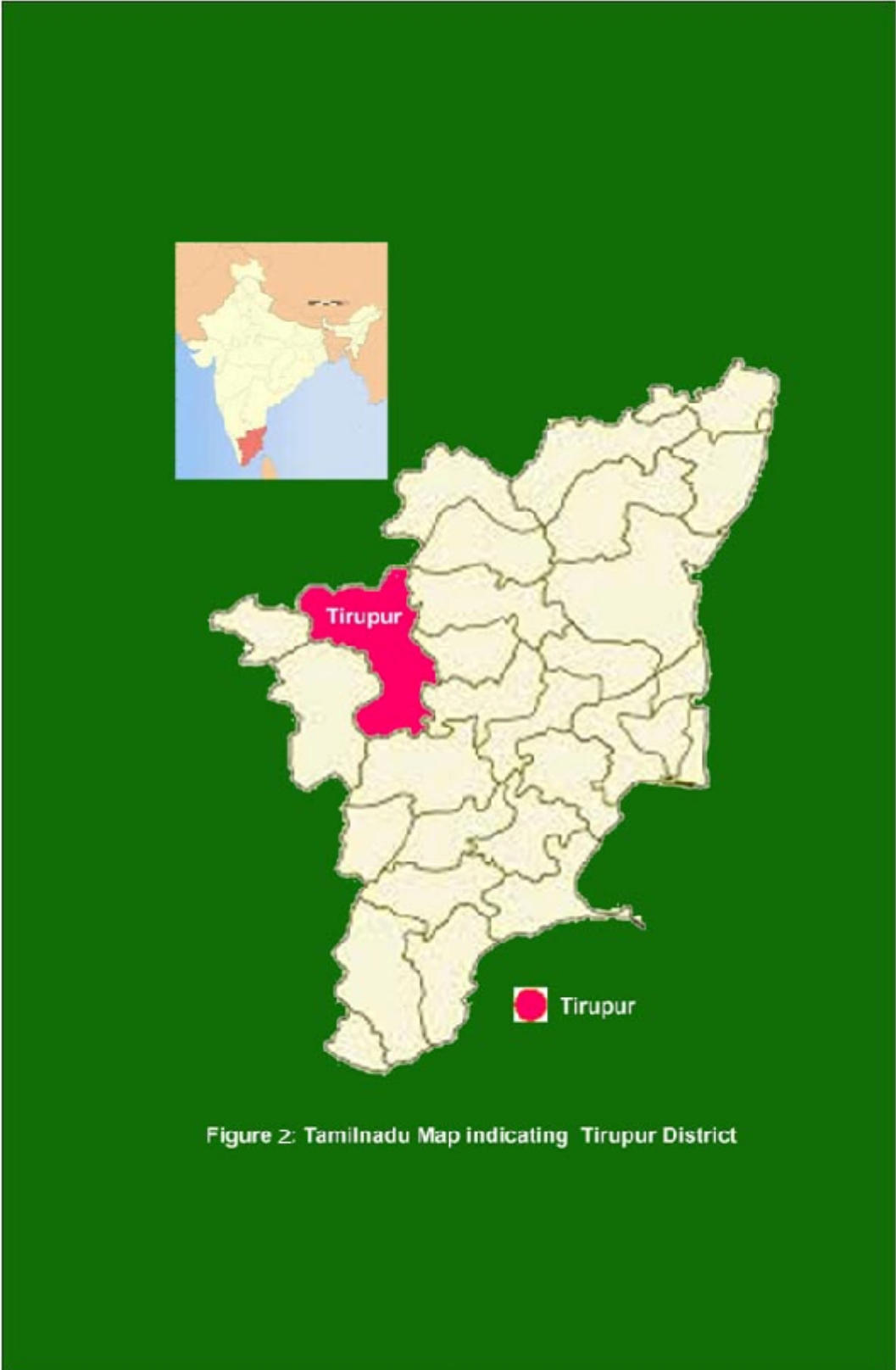


Figure 2: Tamilnadu Map indicating Tirupur District

respondent, personal interviewing is considered as detailed in-depth survey method of responses with better precision. In spite of being time-consuming and costly process, interview method was selected in order to obtain maximum response.

4. Preparation and finalisation of tool

An interview schedule was framed to collect primary data. The schedule having both closed and open end questions, was structured to gather information on the following:

- socio- economic background of the garment workers
- job history of the workers
- body parts discomforts of the workers
- details about accidents at worksite
- safety measures practiced in garment industries
- knowledge, attitude and practice regarding occupational health problems among garment workers
- health problems related to work
- problems of work, worker and work environment and
- strategy to overcome such weakness/problems

A preliminary study called pilot study was conducted on a limited scale with 10 samples before the schedule was finalised in order to gain some primary information and check the suitability of the tool to collect relevant information.

Bordens and Abbott (2005) state that a pilot study is a small-scale replica or full fledged miniature study of the main study. Pre testing helps in enriching the design of the questionnaire and assists in testing the validity and reliability of statistical techniques to be adopted. Based on the result of the pilot study, the interview schedule was modified and finalised for its actual use in the survey (Appendix I).

5. Conduct of the study

An introductory letter was taken by the investigator from the University to selected Garment Industries in Tirupur for prior permission to conduct the study. The investigator met the owners and the workers during their leisure hours and

explained clearly the purpose of the study. The workers were interviewed during the work hours in some units, while in majority they were interviewed during lunch hours or before the start of the day's work. Each interview took about 20-25 minutes. Thus 514 workers employed in 13 units were interviewed for the study (Plate 1).

6. Consolidation and analysis of data

The data gathered from the workers were consolidated and analyzed using Statistical Package for Social Sciences, SPSS (11th version). Analysis such as Percentage analysis, Pearson correlation, 't' test and χ^2 were used to assess the workers' knowledge and health problems. The results are presented under Results and Discussion.

B. Creating Awareness on Occupational Safety and Health

The survey results showed that a considerable number of respondents were employed in unsafe and unhealthy work environment and moreover they were unaware of the importance of occupational safety and health and ergonomics in the workplace. Hence an awareness programme regarding the need to apply ergonomic principles and health practices in the workplace were planned with the following objectives to:

- create awareness on the importance of occupational safety and health and ergonomic principles in the garment industries
- help them to know the occupational health hazards of working in unergonomic workstations
- highlight them on the legal protection to labour
- educate them on work stress and its management

Two different awareness programmes were planned and conducted to create general awareness among public and special awareness for workers specifically in their workplace.

1. Public meeting

One day public meeting was conducted in collaboration with Non-Governmental Organisation (NGO) twice in two consecutive years for public as well as garment workers. Wall posters were stuck on walls in places where



Plate 1: Survey of workers

people gather. Notices were distributed to the public and workers about the meeting. Invitations were printed and sent to various industries, government offices and speakers (Appendix II). Prior permission was got from the police to conduct the meeting. Eminent lawyer, labour officer, nutritionist, yoga master, union leaders, physiotherapist, pulmonologist and field publicity officer were invited as key speakers in the meeting (Plates 2 and 3).

2. Awareness programme for workers

A systematic awareness programme for garment workers were planned and conducted as follows:

- a. Selection of target group
- b. Development of course content
- c. Conduct of the programme
- d. Evaluation of the impact of the programme

a. Selection of target group

According to the willingness, awareness level and cooperation of the workers, five garment industries were selected and proportionately workers were selected from each industry. The selected workers from each industry were divided into smaller groups comprising of 15 - 20 participants for the awareness programme so as to avoid difficulty in gaining knowledge by the receiving end. Altogether 300 workers were selected for awareness programme from five selected garment industries as shown in Table 1.

Table 1: Number of garment workers selected

Sl.No.	Garment Industries	Number of garment workers selected (N=300)
1	Sri Dhanalakshmi Exports	68
2	Sree Lakshmi Knitwear	51
3	S.K.Fashion	59
4	ISS Exports	79
5	Venkaruna Apparels	43



Plate 2: Public Meeting Conducted In the Year 2011



Plate 3: Public Meeting Conducted In the Year 2012

b. Development of course content

An elaborate course content was developed to create awareness among garment workers on the importance and application of occupational safety and health and ergonomic principles. Table 2 presents the course content developed for the awareness programme.

Table 2: Course content

Sl.No.	Topic	Course content	Methods used
1	Good nutrition for healthy living	<ul style="list-style-type: none">• Basic healthy practices like hand washing• Wholesome balanced diet• Simple exercise	Charts, posters, lecture and group discussion
2	Occupation and health	<ul style="list-style-type: none">• Neural problems• Problems with sense organ• Gynaecological problems• Musculoskeletal Disorders (MSDs)• Need for personal protective equipments and safety measures	Charts, posters, pamphlets, booklets, lecture and group discussion
3	Ergonomics to improve work environment	<ul style="list-style-type: none">• Meaning• Concept• Need for ergonomics• Work environment• Ergonomically designed furniture	Lecture, exhibition, posters, booklets and video film show.
4	Legal protection to labour	<ul style="list-style-type: none">• Need for legal protection• The Factory Act, 1948• The Minimum Wages Act, 1948• The Industrial Disputes Act, 1947• The Employee State Insurance Act, 1948• The Maternity Benefit Act, 1961• Generic ethical code of conduct• Amendments made in all Acts	Posters, lecture and group discussion
5	Work stress and its management	<ul style="list-style-type: none">• Meaning and cause• Need for stress management• Techniques to relieve stress through yoga and meditation	Lecture, demonstration and group discussion

c. Conduct of the programme

The awareness programme on occupational safety and health was conducted by the investigator systematically to the target group comprising of 15-20 workers and was repeated twice or thrice depending on the total strength of the workers employed in each industry and also number of workers willing to participate from each garment industry. The awareness programme was thus

being organised during the workers' break periods or at the end of the days' work in the industries. Many audio visual aids were used to create awareness more effectively. Pamphlets and booklets were distributed among the workers for better understanding of the concept (Plate 4, Figure 3a and 3b) and Appendix III).

d. Evaluation of the impact of the programme

Impact of the awareness programme was evaluated using a checklist (Appendix IV) which consisted of statements based on course content. It was administered to the selected garment workers before conducting the awareness programme to find their knowledge on various concepts. The same checklist was readministered to the same workers after conducting the awareness programme and improvement in the knowledge level was assessed. The findings are presented under "Results and Discussions".

C. Assessment of Workplace Hazards and Medical Screening of the Workers

Hazard analysis or hazard assessment is a process in which individual hazards of the workplace are identified, assessed and controlled/ eliminated as close to source (location of the hazard) as reasonable and possible (Jadab, 2012). This part of the study includes: work environment, work posture of the workers, hazard identification and risk analysis and medical screening of the workers

1. Work environment

The work environment includes all the parameters such as lighting, noise, temperature and humidity. Thus to assess the work environment all these parameters were studied in depth to arrive at valid conclusions. Plate 5 illustrates the assessment of work environmental parameters.

a. Measurement of lighting

The illumination level was measured with a hand held digital lightmeter (TES 1332). All the readings were taken at the Point of Operation (POO). The activity areas were divided into approximate grid and for readings, an average value was obtained.



Plate 4: Special Awareness for Garment Workers



அய்யாசிலிம்மம் மகலி பங்கலைக் கரம் மற்றம் தம் சமூக நல அறக்கட்டளை துணைத்து பின்னலாகை, தொழிலாளர் நல விழிப்புணர்வு கருத்தரங்கம் நேற்று நடத்தியது. இதில் அறக்கட்டளை நிர்வாக இயக்குனர் ஈரங்கிருஷ்ணன் பேசினார்.

25/04/2011

பனியன் தொழிலாளருக்கு விழிப்புணர்வு கருத்தரங்கு

அனுப்பாளன், டி. 25- சண்முகபுரம் ஆகியவர்கள் அலிதாசிலிம்மம் மகலி பேசினார். பனியன் தொழிலாளர்களுக்கு உடல் நல குறைபாடு, அமைதி போக்கு, அனுப்பி பாகை மத்திய நடத்தி. தம் சமூக நல அறக்கட்டளை நிர்வாக இயக்குனர் ஈரங்கிருஷ்ணன் தலைமையில் நடைபெற்றது. பனியன் தொழிலாளர்களுக்கு உடல் நல குறைபாடு, அமைதி போக்கு, அனுப்பி பாகை மத்திய நடத்தி. தம் சமூக நல அறக்கட்டளை நிர்வாக இயக்குனர் ஈரங்கிருஷ்ணன் தலைமையில் நடைபெற்றது. பனியன் தொழிலாளர்களுக்கு உடல் நல குறைபாடு, அமைதி போக்கு, அனுப்பி பாகை மத்திய நடத்தி. தம் சமூக நல அறக்கட்டளை நிர்வாக இயக்குனர் ஈரங்கிருஷ்ணன் தலைமையில் நடைபெற்றது.



பின்னலாகை, தொழிலாளர்களுக்கான கருத்தரங்கு தம் சமூக நல அறக்கட்டளை ஈரங்கிருஷ்ணன் நிர்வாக இயக்குனர் ஈரங்கிருஷ்ணன் பேசினார். 26/04/2012

Figure 3a: Newspaper Clippings on Creating Awareness among Garment Workers



Figure 3b: Newspaper Clippings on Intervention Programme among Garment Workers



Measuring lighting level using digital lightmeter



Estimating noise exposure level using precision sound level meter



Recording room temperature and humidity levels using digital thermohygro clock

Plate 5: Assessment of Work Environmental Parameters

b. Measurement of noise

An initial walk around survey was conducted to estimate the noise exposure level using precision sound level meter (TES 1350) set on the 'A' weighting scale. The microphone was placed in the employees hearing zone. Averages of a minimum of three observations were taken to ensure reliability of the recorded values.

c. Measurement of temperature and humidity

The room temperature and humidity levels were recorded simultaneously using a hand held digital thermohygro clock.

d. Furniture used

The furniture used by garment workers were varied in their size, shape and dimensions. There was no uniformity among the furniture used in the same units. However to assess the physical and postural stress, the dimensions of the furniture used by the workers were recorded.

2. Work posture

The postures adopted by the garment workers were awkward and in some cases it resulted in upper limb disorders. The work posture was assessed as given below:

a. Assessment using RULA

For postural assessment, Rapid Upper Limb Assessment (RULA) method also known as pen-paper observational method was chosen for the present study. RULA is a survey method developed for use in ergonomic investigations of workplaces where work related upper limb disorders are reported. It is a screening tool used to assess biomechanical and postural loading on the whole body with particular attention to the neck, the trunk and the upper limbs. This tool requires no special equipment. The method is quick and easy to administer and can be applied in field situations without interruption of the work. This tool has been widely used in both industrial and office settings by ergonomists and physiotherapists. Reliability studies have been conducted using RULA on groups of sewing machine operators and Visual Display Unit (VDU) operators.

- **Identification of tasks and postures for assessment**

The tasks and postures for assessment were identified by observing the worker during several work cycles. The postures held for the longest duration of work cycle or where the highest loads occurred were selected. In certain cases, where the work cycle was long or the postures were varied, assessment was done at regular intervals.

To conduct the assessment by RULA system, in each workstation, the worker was videotaped during his/her routine job activities. After recording the video, it was cropped after every ten seconds to get snapshots for the analysis of posture of the worker. Thirty workers were selected randomly from six sections namely pattern making, cutting, stitching, checking, ironing and packing of garments of the selected garment units making it a total of 180. Hence snapshots of 180 workers working in six sections were obtained and analyzed.

- **Estimation of posture score**

For estimating the posture score, the RULA Employee Assessment Work Sheet developed by McAtamney and Corlett (1993) was used. Figures 4 and 5 presents RULA scoring sheet. For each posture, the investigator recorded the posture scores for the upper arm, the lower arm, the wrist and the wrist twist in the columns provided and the posture score 'A' was calculated using Table 'A'. Similarly posture score 'B' was calculated from the scores from neck, the trunk and using Table 'B'. Later the muscle score and the force score were added to posture scores 'A' and 'B' to arrive at scores 'C' and 'D'. For operations with one hand, either right or left, only one assessment was needed, while separate assessments for the right hand and the left hand were needed in cases where both the hands were used for performing the operations.

- **Computation of grand score and action level**

The third stage of RULA was to incorporate both scores 'C' and 'D' into a grand score whose magnitude provided a guide to the priority for subsequent investigation. Each possible combination of score 'C' and 'D' was given a rating called a grand score of 1-7 based upon the estimated risk of injury due to musculoskeletal loading. This grand score was obtained using Table 'C'.

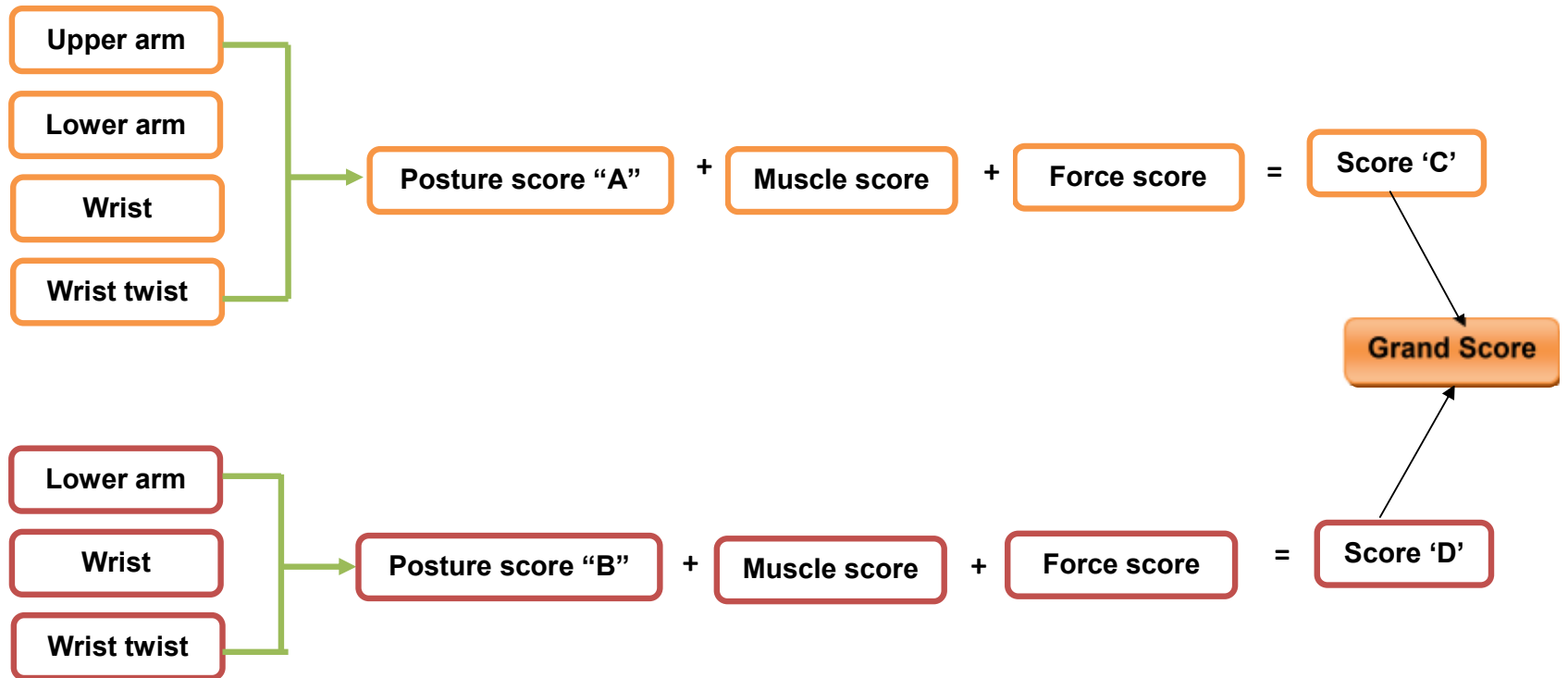


Figure 4 : RULA Scoring Sheet

Complete this worksheet following the step-by-step procedure below. Keep a copy in the employee's personnel folder for future reference.

A. Arm & Wrist Analysis

Step 1: Locate Upper Arm Position

Step 1a: Adjust...
If shoulder is level = 0
If upper arm is vertical = 1
If arm is supported or person is leaning = 1

Step 2: Locate Lower Arm Position

Step 2a: Adjust...
If arm is resting on a surface = 1
If arm is outside of body = 1

Step 3: Locate Wrist Position

Step 3a: Adjust...
If hand is held from the palm = 1

Step 4: Wrist Twist
If wrist is twisted mainly in mid-range = 1
If wrist is at or near end of twisting range = 2

Step 5: Look-up Posture Score in Table A
Use values from steps 1, 2, 3 & 4 to locate Posture Code in Table A.

Step 6: Add Muscle Use Score
If all motions are moderate or less (range from 1 to 4) = 1
If motion repeated or constant (range from 1 to 4) = 1

Step 7: Add Force/Load Score
If motions made by exerting force = 40
If load is 10 lb or more from both = 4
If load is 10 lb or more on one hand = 40
If force from 50 lb load is repeated or constant = 4

Step 8: Find Row in Table C
Use the posture score from Step 5 and the force/load analysis score from Step 7 to find the row in Table C.

SCORES

Table A

Upper Arm	Lower Arm	Wrist Flexion	Wrist Extension	Wrist Twist	Muscle Use	Force/Load
1	1	1	1	1	1	1
2	2	2	2	2	2	2
3	3	3	3	3	3	3
4	4	4	4	4	4	4
5	5	5	5	5	5	5
6	6	6	6	6	6	6
7	7	7	7	7	7	7
8	8	8	8	8	8	8
9	9	9	9	9	9	9
10	10	10	10	10	10	10
11	11	11	11	11	11	11
12	12	12	12	12	12	12
13	13	13	13	13	13	13
14	14	14	14	14	14	14
15	15	15	15	15	15	15
16	16	16	16	16	16	16
17	17	17	17	17	17	17
18	18	18	18	18	18	18
19	19	19	19	19	19	19
20	20	20	20	20	20	20
21	21	21	21	21	21	21
22	22	22	22	22	22	22
23	23	23	23	23	23	23
24	24	24	24	24	24	24
25	25	25	25	25	25	25
26	26	26	26	26	26	26
27	27	27	27	27	27	27
28	28	28	28	28	28	28
29	29	29	29	29	29	29
30	30	30	30	30	30	30
31	31	31	31	31	31	31
32	32	32	32	32	32	32
33	33	33	33	33	33	33
34	34	34	34	34	34	34
35	35	35	35	35	35	35
36	36	36	36	36	36	36
37	37	37	37	37	37	37
38	38	38	38	38	38	38
39	39	39	39	39	39	39
40	40	40	40	40	40	40
41	41	41	41	41	41	41
42	42	42	42	42	42	42
43	43	43	43	43	43	43
44	44	44	44	44	44	44
45	45	45	45	45	45	45
46	46	46	46	46	46	46
47	47	47	47	47	47	47
48	48	48	48	48	48	48
49	49	49	49	49	49	49
50	50	50	50	50	50	50

Table B

Posture Code	Injury Risk Score					
	1	2	3	4	5	6
1	1	1	1	1	1	1
2	2	2	2	2	2	2
3	3	3	3	3	3	3
4	4	4	4	4	4	4
5	5	5	5	5	5	5
6	6	6	6	6	6	6
7	7	7	7	7	7	7
8	8	8	8	8	8	8
9	9	9	9	9	9	9
10	10	10	10	10	10	10
11	11	11	11	11	11	11
12	12	12	12	12	12	12
13	13	13	13	13	13	13
14	14	14	14	14	14	14
15	15	15	15	15	15	15
16	16	16	16	16	16	16
17	17	17	17	17	17	17
18	18	18	18	18	18	18
19	19	19	19	19	19	19
20	20	20	20	20	20	20
21	21	21	21	21	21	21
22	22	22	22	22	22	22
23	23	23	23	23	23	23
24	24	24	24	24	24	24
25	25	25	25	25	25	25
26	26	26	26	26	26	26
27	27	27	27	27	27	27
28	28	28	28	28	28	28
29	29	29	29	29	29	29
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34	34	34	34	34	34	34
35	35	35	35	35	35	35
36	36	36	36	36	36	36
37	37	37	37	37	37	37
38	38	38	38	38	38	38
39	39	39	39	39	39	39
40	40	40	40	40	40	40
41	41	41	41	41	41	41
42	42	42	42	42	42	42
43	43	43	43	43	43	43
44	44	44	44	44	44	44
45	45	45	45	45	45	45
46	46	46	46	46	46	46
47	47	47	47	47	47	47
48	48	48	48	48	48	48
49	49	49	49	49	49	49
50	50	50	50	50	50	50

Table C

Posture Code	1	2	3	4	5	6	7
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9
10	10	10	10	10	10	10	10
11	11	11	11	11	11	11	11
12	12	12	12	12	12	12	12
13	13	13	13	13	13	13	13
14	14	14	14	14	14	14	14
15	15	15	15	15	15	15	15
16	16	16	16	16	16	16	16
17	17	17	17	17	17	17	17
18	18	18	18	18	18	18	18
19	19	19	19	19	19	19	19
20	20	20	20	20	20	20	20
21	21	21	21	21	21	21	21
22	22	22	22	22	22	22	22
23	23	23	23	23	23	23	23
24	24	24	24	24	24	24	24
25	25	25	25	25	25	25	25
26	26	26	26	26	26	26	26
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28	28	28	28	28	28	28	28
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34	34	34	34	34	34	34	34
35	35	35	35	35	35	35	35
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38	38	38	38	38	38	38	38
39	39	39	39	39	39	39	39
40	40	40	40	40	40	40	40
41	41	41	41	41	41	41	41
42	42	42	42	42	42	42	42
43	43	43	43	43	43	43	43
44	44	44	44	44	44	44	44
45	45	45	45	45	45	45	45
46	46	46	46	46	46	46	46
47	47	47	47	47	47	47	47
48	48	48	48	48	48	48	48
49	49	49	49	49	49	49	49
50	50	50	50	50	50	50	50

B. Neck, Trunk & Leg Analysis

Step 9: Locate Neck Position

Step 9a: Adjust...
If neck is level = 0
If neck is above or below = 1

Step 10: Locate Trunk Position

Step 10a: Adjust...
If trunk is vertical = 0
If trunk is tilted = 1

Step 11: Legs

If legs & feet supported or balanced = 1
If not = 2

Step 12: Look-up Posture Score in Table B

Use values from steps 9, 10 & 11 to locate Posture Code in Table B.

Step 13: Add Muscle Use Score

If posture mainly static or constant = 1
If motion repeated or constant = 1

Step 14: Add Force/Load Score

If motions made by exerting force = 40
If load is 10 lb or more = 4
If load is 10 lb or more on one hand = 40
If force from 50 lb load is repeated or constant = 4

Step 15: Find Column in Table C

The completed score from the Neck, Trunk & Leg analysis is used to find the column in Table C.

Final Score =

Subject: _____ Date: ____/____/____

Company: _____ Department: _____ Scorer: _____

FINAL SCORE: 1 or 2 = Acceptable; 3 or 4 investigate further; 5 or 6 investigate further and change soon; 7 investigate and change immediately

Source: McAtamney, L. & Corlett, T. N. (1993) RULA: a simple method for the investigation of work-related upper limb disorders. Applied Ergonomics, 24(2) 91-99
 © Professor Alan Haslegrave, Coventry University, Feb. 2007

Figure 5: RULA Employees Assessment Worksheet

The grand scores revealed the level of estimated risk of injury and the action to be taken there upon. The inference made of the grand scores is shown in Table 3.

Table 3: Inference from the grand score for posture

Grand scores	Action to be taken
1 or 2	Acceptable
3 or 4	Investigate further
5 or 6	Investigate further and change soon
7	Investigate and change immediately

The postures adopted by workers at work in all sections of the garment industry are illustrated in Plate 6a and 6b.

b. Assessment using postural discomfort

Postural discomfort was one of the crucial problems of the workers employed in garment industries. This was assessed by using Corlett and Bishop's (1976) method of body mapping. This is one of the most common and widely accepted methods of obtaining information about body discomfort. Thirty garment workers from six sections namely pattern making, cutting, stitching, checking, ironing and packing who were willing to co-operate with the investigator in the analysis were purposively chosen for the study.

- **Description of the method**

A body map as shown in Figure 6 was used for the study. It was handed over to the workers with a five point scale, with the extremes anchored by the terms "no discomfort" and "extreme discomfort", to each of the workers asking him/her to judge the present level of overall discomfort. Following this, the worker was asked to indicate the part/parts of the body most uncomfortable and the next most uncomfortable part and so on until no more parts were reported. The procedure was carried out at regular intervals, namely before the starting of work, before mid morning tea, before lunch, before afternoon tea and before the end of work throughout the day to study the growth of discomfort as a result of the work. The mean weighted score was estimated for each part of the body experiencing pain and analyzed further to make a realistic appraisal of the body discomforts of the workers in each section.



Pattern making section



Cutting section



Stitching section

Plate 6a: Postures selected for RULA



Checking section



Ironing section



Packing section

Plate 6b: Postures selected for RULA

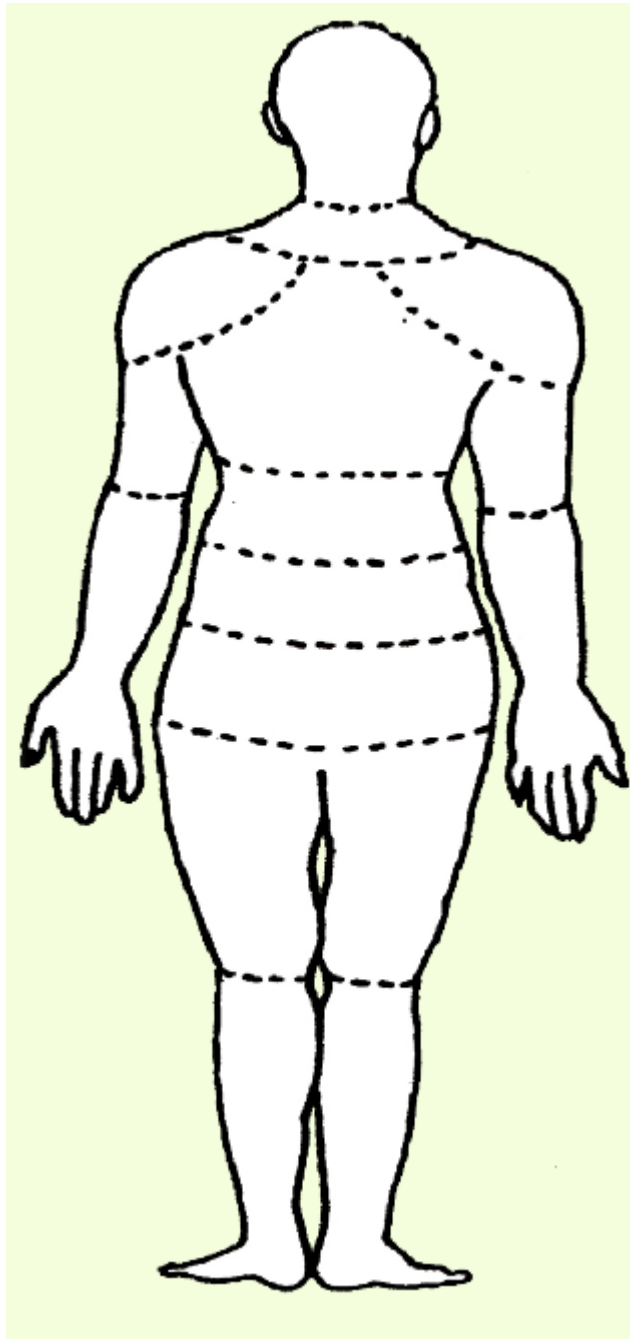


Figure 6: Body Map

3. Hazard identification and risk analysis

For health and hazard and risk analysis, a standardised format called “Identification of Health and Safety Hazards and Evaluation of Health and Safety Risks” used in industries seeking OSHAS certification (British Standards Institutions, 1996; Tamil Nadu Control of Industrial Major Accident Hazards Rules, 1994) was used. Figure 7 gives an overview of the Hazard Identification and Risk Assessment Process with reference to the chosen industry.

- **Identification of Activities**

This phase included identification and listing of all the tasks performed in various sections of a garment manufacturing unit. Tasks that were routine, new or occasionally performed and all those that led to injury, environmental damage or property were enumerated. The activities done outside the premises of the garment manufacturing unit were totally excluded, though in a few cases risks were noticed therein. Thus only those tasks that were performed inside the different sections of the factory were shortlisted.

- **Hazard Identification**

Review of related documents and accident reports followed by personal observation and sharing of the experiences of the workers and the supervisors formed the basis of hazard identification. A single activity may pose a number of hazards. For example, operation of a sewing machine can cause hazards like exposure to heat, postural stress and needle pricking. For each hazard, a separate analysis was performed. Depending on whether the hazard occurred during normal operation or in abnormal situations like machine malfunction or during emergency situations like disaster and explosion the hazards were labelled N, Ab, and E respectively. A single activity can cause hazards in all the three situations, i.e., in N, Ab and E situations and, in such cases, all the incidents were treated separately. The next step in this hazard analysis was to ascertain the effect of the hazard – whether direct or indirect. Most of the hazards occurring inside the unit were direct. The indirect hazards were those which did not affect the workers directly, but affected the factory or the community at large. Those activities posing both direct and indirect hazards were to be listed twice indicating separately each category of the hazard.

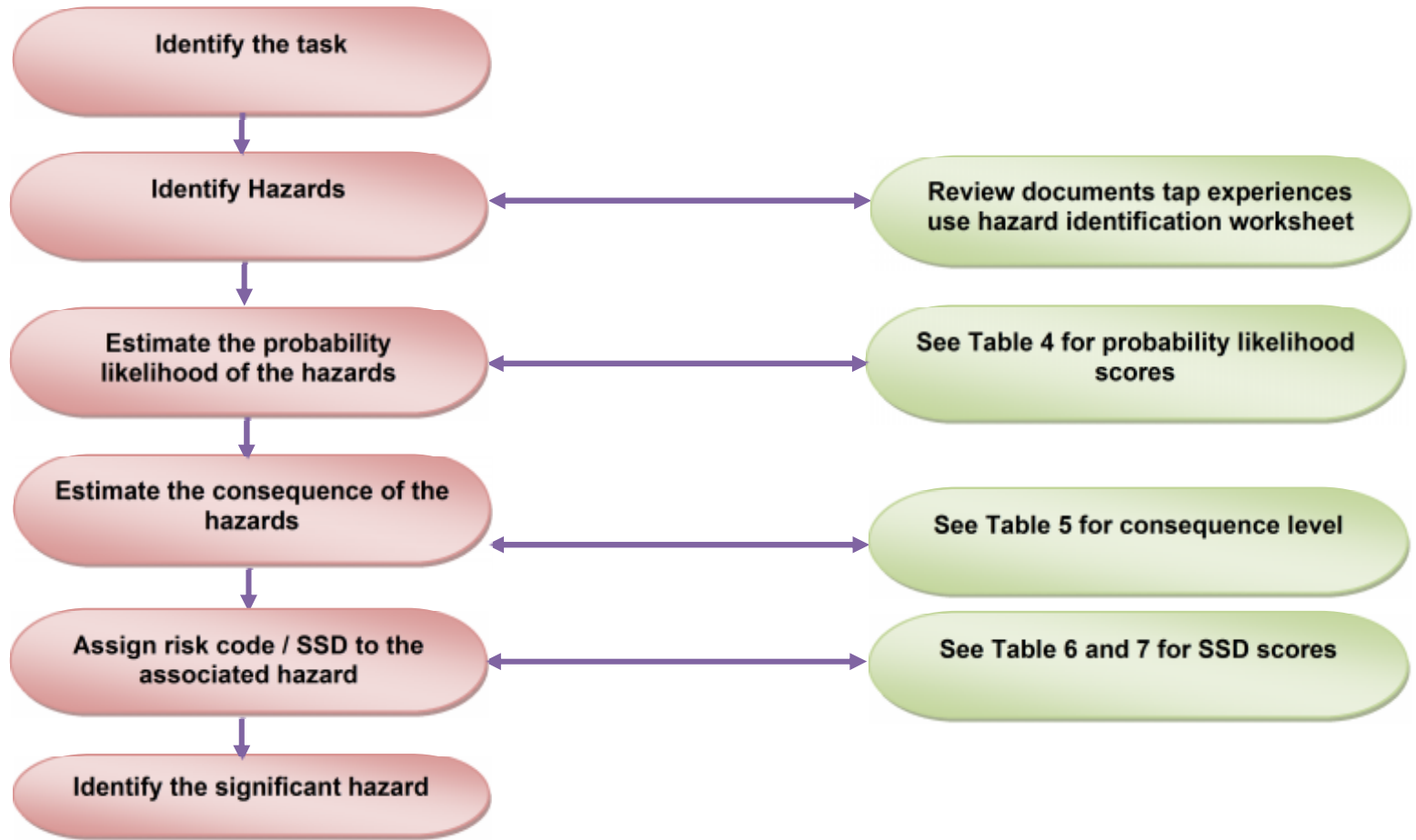


Figure 7: Overview of the Hazard Identification and Risk Assessment Process

- **Estimating the probability / likelihood of the hazards**

After enumerating the activity and the associated hazards, the likelihood of each hazard was computed from the periodicity of its occurrence. The occurrence was rated from very likely hazards to highly unlikely hazards. The risk likelihood score of each hazard was calculated following the guidelines given in Table 4.

Table 4: Estimation of risk likelihood

Weightage / Scores	Probability	Risk Likelihood
1	Less than once in a month	Highly unlikely
2	More than once in a month but less than once in a week	Unlikely
3	More than once in a week but less than once in a day	Likely
4	More than once in a day	Very likely

- Estimation of the exposure consequences of the hazards

Based on the exposure consequences, the hazards requiring first aid or absence from work or causing temporary or permanent disabilities were ranked as slightly harmful, very harmful and extremely harmful as shown in Table 5. To enable further understanding of the hazards, remarks were recorded in the column provided in the format against the specific hazard.

Table 5: Risk consequence level

Weightage	Effect	Descriptor
1	First aid required, but worker does not leave the site / premises	Slightly Harmful
2	Minor injury – requires absence from work for less than 48 hours (Non reportable)	Harmful
3	Major injury, temporary disability – requires more than 48 hours' absence from work (Reportable)	Very Harmful
4	Fatal or permanent disability or major injuries involving large number of people (Reportable)	Extremely Harmful

- Risk Evaluation

The risk evaluation was done in two stages, namely, “Concern” and “SSD Scores”. “Concern” here refers to Domino Concern, Legal Concern and Chronic Concern. Domino Concern refers to the hazards that have a set of chain reactions, such as one thatched hut catching fire. Legal Concern indicates whether the hazard is illegal or is regulated by law, like noise levels in industries. Chronic Concern indicates the hazard that accumulated over time and one day becomes a problem, which may or may not be irreversible, e.g., lead poisoning. If the hazards are covered by one of the concerns, then the hazard is considered to be a “significant” one based on the qualitative assessment of the three concerns, and no further quantitative analysis (SSD scores) are needed. If the hazards are not covered by any of these concerns, then quantitative analysis in the form of calculating SSD Scores is need to evaluate the hazards for “significance”.

SSD scores refer to the Scope, Severity and Duration of the hazard. For Scope (Sc), the scores ranged from 1 to 4, depending on whether the hazards occurred on the spot, section and plant or outside. The Severity (Sv) score was computed from the consequence level score and risk likelihood score by adding the two values based on the ratings of the hazard on these criteria. As given in Table 6, the risk severity score of a hazard ranged from 2 to 8.

Table 6: Risk Severity Assessment

Risk Likelihood (from Table 3)	Risk Consequence level (from Table 3)			
	Slightly Harmful = 1	Harmful = 2	Very Harmful = 3	Extremely Harmful = 4
Highly unlikely = 1	Trivial risk (2)	Tolerable (3)	Moderate (4)	Substantial (5)
Unlikely = 2	Tolerable (3)	Moderate (4)	Substantial (5)	High risk (6)
Likely = 3	Moderate (4)	Substantial (5)	High risk (6)	Very high risk (7)
Very likely = 4	Substantial (5)	High risk (6)	Very high risk (7)	Intolerance (8)

The Duration (Du) scores also ranged from 1 to 4, depending upon the duration of the hazard as given in Table 4. The risk severity scores from Table 6 were integrated with the values in Table 7 to get the total risk value of the hazard.

Table 7: SSD Evaluation Criteria for Risks

Weightage	Scope (Sc)	Weightage	Severity (Sv)	Weightage	Duration (Du)
1	Spot	2	Trivial	1	< Minute
2	Section	3	Tolerable	2	> Minute < Hours
3	Plant	4	Moderate	3	> Hours < 8 Hours
4	Outside	5	Substantial	4	> 8 Hours
		6	High		
		7	Very high		
		8	Intolerable		

The Scope, Severity and Duration scores were added to confirm whether the reported risks were significant or not significant. As per the chosen trigger level, if any one of the concerns like DC, CC or LC was recorded or when the SSD Score was 8 or more the risk was classified as significant. Following the guidelines, the SSD scores of each hazard experienced by the workers were computed. All those hazards with scores of 8 and above were identified and analysed further.

4. Health Check-up

The clinical tests were conducted to assess the health status of the workers as given below:

a. Body Mass Index

The Body Mass Index of all the surveyed workers (N=514) was calculated by their height and weight. The metric BMI formula accepts weight measurements in kilograms and height measurements in meters.

$$\text{BMI (Kg/m}^2\text{)} = \text{Weight in kilograms/height in meter}^2$$

BMI	Weight Status
<18.5	Underweight
18.5 – 24.9	Normal
25 – 29.9	Overweight
>=30	Obese

b. Blood pressure and blood glucose

Blood pressure was recorded using digital blood pressure monitor and blood glucose level using glucometer of the surveyed garment workers. Blood glucose was recorded randomly (Plate 7).

c. Spirometry Test

There is a sizable medical research literature regarding the occupational impact on the respiratory function of workers in various occupations like coal miners, cotton textile workers, welders, farm workers, chemical workers, cement workers, and others. Chronic obstructive pulmonary disease (COPD) is defined as a disease state characterised by progressive airflow limitation that is not fully reversible, and is associated with an abnormal inflammatory response of the lungs to noxious particles or gases, primarily cigarette smoke (Celli and MacNee, 2004). The spirometric testing should be determined for early detection of COPD. It is due to the fact that COPD is one of the leading cause of morbidity and mortality in industrialised countries worldwide, and is emerging as being increasingly important in developing countries (Calverley and Georgopoulous, 2006). Assuming that current trends in mortality continue, COPD will move from being the sixth leading cause of death worldwide in 1990 to the third in 2020 (Murray and Lopez, 1997). No earlier study among garment workers employed in Tirupur garment industries, India in terms of pulmonary function tests has been reported. Hence, the present study was undertaken with the following objectives to:

- examine the association between socio-economic variables, occupational history and clinical history with levels of COPD in experimental and control groups
- assess the prevalence of airway obstruction among experimental and control groups
- find the effectiveness of bronchodilator inhalation between experimental group and control group

Ethical approval was obtained from the Ethics Committees of the University to which the candidate belonged (Appendix V). Written, informed consent was provided by all subjects. The spirometry test was carried out under



Recording blood pressure



Examining blood glucose

Plate 7: Health Check-up

the supervision of a leading Pulmonologist working in Tirupur Government Hospital. The pulmonary function tests was carried out with a computerized spirometer (Spirobank II S/N 004546) used in the standard laboratory methods. The spirometer was calibrated regularly. Out of 514 workers surveyed, 200 workers (nearly 40 per cent) were selected for spirometry test. The selected 200 subjects working in garment industries were considered as experimental group while 50 subjects who were not workers in garment industries, as control group.

Inclusion Criteria of the study were as follows:

- Working in garment industry for at least one year
- Subjects of both sexes who were willing to participate

Exclusion Criteria of the study were as follows:

- Subjects who were working in garment industry for a period of less than one year
- Subjects with respiratory disease like tuberculosis and pneumonia
- Subjects with cardiac and cardio vascular disease
- Less than 15 years of age

The workers' age, height and weight were recorded to use in the calculation of reference values. The details of demographic and respiratory symptoms of garment workers were collected using an interview schedule (Appendix VI).

The following activities should be preferably avoided prior to examination.

- ✓ Smoking within at least one hour of testing
- ✓ Consuming alcohol within four hours of testing
- ✓ Performing vigorous exercise within 30 minutes of testing
- ✓ Wearing clothing that substantially restricts full chest and abdominal expansion
- ✓ Eating a large meal within 2 hours of testing

All the pulmonary function tests were done on the subjects comfortably in a seated position. During the test, the subject was adequately encouraged to perform their optimum level and also a nose clip was applied during the entire maneuver. Tests were repeated three times and the best matching results were considered for analysis. The parameters measures by the apparatus were the Forced Vital Capacity (FVC),

Forced Expiratory Volume in 1st second (FEV₁) and FEV₁/FVC. After initial spirometry, a bronchodilatory test was performed with inhalation of Salbutamol 200 µg to all experimental subjects, administered via a metered - dose inhaler with a spacer. After an additional 15 minutes, postbronchodilator spirometry was performed (**Plate 8**).

In accordance with the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines, irreversible airflow obstruction was defined as a postbronchodilator FEV₁/FVC ratio of < 0.70, which corresponds to GOLD Stage I (Fabbri and Hurd, 2003). Airflow obstruction was classified according to the GOLD criteria. Severity of COPD was distinguished in four stages:

- Mild (GOLD Stage I): FEV₁/FVC ratio < 0.70 and FEV₁ > 80% predicted
- Moderate (GOLD Stage II): FEV₁/FVC ratio < 0.70 and FEV₁ 50% - 80% predicted
- Severe (GOLD Stage III): FEV₁/FVC ratio < 0.70 and FEV₁ 30% - 50% predicted
- Very severe (GOLD Stage IV): FEV₁/FVC ratio < 0.70 and FEV₁ < 30% predicted or FEV₁ < 50% with signs of chronic respiratory failure

The values for FEV₁/FVC and FEV₁ were postbronchodilator, and were expressed as a percentage of predicted. The GOLD definition of reversibility was used, ie, FEV₁ increase of 200 mL and 12 per cent improvement above baseline FEV₁ following the administration of bronchodilator. The participants identified to have COPD were sent for further investigation and diagnosis at Tirupur District TB Centre, Government Hospital, Tirupur.

d. Heart rate of workers

Heart rate is one of the indices of assessing the physical fitness of an individual. The resting, working and recovery heart rate of garment workers were recorded using S-410 polar Heart Rate monitor. The working heart rate was recorded for the complete work cycle or for a period of eight hours. Heart rate of 30 workers were recorded in each of the sections namely pattern making, cutting, stitching, checking, ironing and packing of garments (**Plate 9**).



Survey of the subjects



Subject performing Spirometry test



Spirobank II S/N 004546



Subject performing bronchodilatory test



Consultation by Pulmonologist

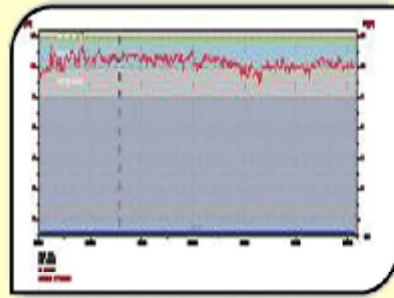


Spirometry Report

Plate 8: Spirometry Test



Polar S410 Heart Rate Monitor



Graph showing heart rate data of a garment worker



Subject performing heart rate study

Plate 9: Heart Rate Studies of Garment Workers

D. Designing and Evaluating Ergonomic Furniture

Among all the activities carried out by the workers, stitching and checking of garments were found to be most strenuous work (Plate 10 and 11). This was proved by three assessment tools such as Rapid Upper Limb Assessment (RULA), Body Part Discomfort (BPD) and Hazard Identification and Risk Analysis [HIRA].

Introducing ergonomic table

The table developed by Ganguli et al. (2009) for checking workers were adopted for the study and modified based on the suggestions given by the workers. The cost for modified table was `20,000/-.The cost estimation of the modified is given in Appendix VII. The details of the modified ergonomic table are presented in the next chapter. The modified ergonomic table were given to ten workers to use for a period of two months. Evaluation of the improved ergonomic table for checking workers were carried out using the following headings namely RULA, BPD, Heart rate studies and worker productivity and presented in the next chapter.

• Designing ergonomic chair

Numerous previous studies report about consideration musculoskeletal problems due to the static postures of sewing machine operators, which have to be maintained during the whole working period, as well as those due to the highly repetitive manual tasks performed. For designing ergonomic chair the body measurements in sitting position is required. Hence the anthropometry measurement of the stitching workers were taken to determine anthropometric dimensions of male and female stitching workers for proper workstation design and to compare with other published data for other population.

Fifty male and 50 female stitching machine operators were selected for the study. All subjects were requested to wear light clothing without foot wears. For sitting dimensions, subjects were requested to sit erect on a chair without armrests, with knees bent 90° , and feet flat on the surface, facing forward, and arms hanging beside the body. Twelve anthropometric dimensions of human body in the sitting posture were identified, and hence became the target anthropometric dimensions that were measured for the ergonomic chair for



Plate 10 : Checking of Stitched Garments using Conventional Checking Table



Plate 11: Workers Using Conventional Chair

stitching machine operators as suggested by Mirmohammadi et al. (2008). The definition of anthropometric dimensions is shown below:

Definition of anthropometric data

Anthropometric dimensions	Definition
Sitting height	This is the vertical distance between the seat surface and the top of the head with subject sitting erect, looking straight ahead, and knee at the right angles.
Sitting eye height	The vertical distance from the seat surface to the outer corner of the right eye.
Sitting shoulder height	The vertical distance from the seat surface to the tip (acromion) of the shoulder.
Elbow rest height	The vertical distance from the sitting surface to the lowest point of the right elbow, with the elbow flexed at 90 degrees.
Upper lumbar	The vertical distance between the first lumbar region to sitting surface with subject sitting erect.
Lower lumbar	The vertical distance between the sitting surface and the 5 th lumbar landmark with subject sitting erect.
Thigh clearance	The vertical distance from the sitting surface to the highest point on the top of the right thigh, with the knee flexed at 90 degrees.
Sitting popliteal height	The vertical distance from the floor to the underside of the thigh directly behind the right knee with the knees flexed at 90 degrees.
Sitting buttock popliteal height	The horizontal distance from the back of the buttocks to back of the right knee just below the thigh, when sitting with the knee flexed at 90 degrees.
Buttock knee length	The horizontal distance from the most posterior aspect of the right buttock to the most anterior aspect of right knee.
Thigh to thigh length	The maximum horizontal distance across the thighs, knees touching lightly to each other with subject sitting erect, thighs parallel and completely supported by the sitting surface.
Hip breadth	The maximal horizontal breadth across the hips or thighs, whatever is greater.

All the above mentioned measurements for each subject were taken thrice (Appendix–VIII). The data was analyzed statistically using Statistical Package for the

Social Sciences (SPSS) for Windows version 16.0. All the data were processed separately for male and female garment workers and descriptive values, 5th, 50th and 95th percentile values, mean, median, mode, standard deviation and range were calculated and presented in the next chapter.

Based on the above results, an **ergonomic chair** for stitching workers was designed. The developed prototype chair was given to the workers for field trial. Later based on the opinions of the researchers, workers and designers the prototype I and prototype II chair was modified (Plate 12). The cost estimation of the designed chair was `2300. The details of the cost estimation were given in Appendix IX. The special features of the ergonomic chair designed by the investigator is shown in Table 8 and Figure 8.

Table 8: Special features of the ergonomic chair

Parameters	Dimensions	Remarks
Height	106cm	Based on 95 th percentile values of sitting height and sitting popliteal height
Width	38cm	95 th percentile of hip breadth
Length	40cm	5 th percentile of buttock popliteal length
Seat back angle	90 ⁰	Seat back angle more than 90 ⁰ will not be useful for stitching workers who have to work being in forward tilted positioned
Seat	No cushion provided	To prevent excessive heat while sitting for a prolonged time and also avoid gastrointestinal problems to some extent
Length of the cushion	30cm	A height adjustable lumbar support is not necessary since the height of a fixed lumbar support can be optimized to contact the lumbar spines of a wide range of users. Thirty centimeter would help in lumbo-thoracic support.
Thickness of cushion of the back rest	4cm	Lumbar support is achieved by countering the back rest with cushion of 4-5cm thick with hollow in buttock area (20cm). This hollow prevent user's pelvic from sliding forward
Hand rest	Not provided	No hand rest is needed as the hands are always at the work surface which is just as the elbow height
Foot rest	16.5cm	Similar as the pedal of the working table (to operate the sewing machine by foot)



a. Prototype I



b. Prototype II

Plate 12 : Ergonomic Chair Designed

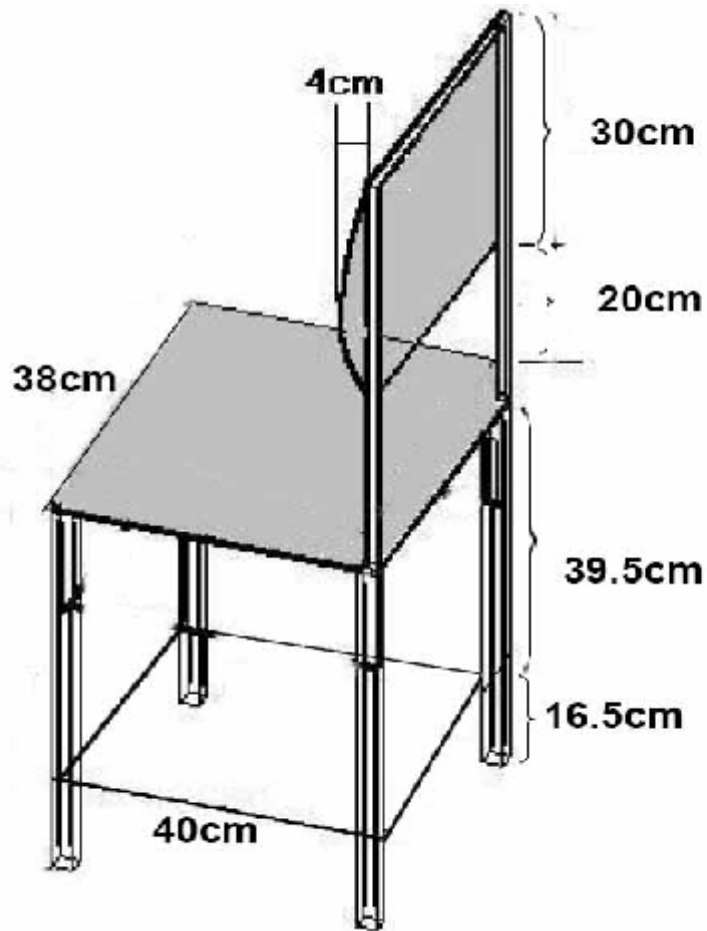


Figure 8: Model of Chair for Stitching Worker

Thus the modified ergonomic chair was given to ten workers to use for a period of two months. Evaluation of the ergonomic chair for stitching machine operators were carried out using the following headings namely RULA, BPD, Heart rate and worker productivity.