Anthropometric Measurement & Assessment of Occupational Ergonomic Risks of Handloom Weaving in Varanasi District

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(ICSSR sponsored IMPRESS project under the domain Health and Environment)

Abstract
Handloom weaving is one of the oldest surviving traditional crafts in Varanasi and generates a large number of employments. Poor posture is a risk for musculoskeletal problems of the neck, shoulders, and lower back and lengthy hours of static work with awkward posture at traditionally designed looms can lead to a high prevalence of musculoskeletal problems. Keeping in view these facts the present research was planned and a survey was conducted to select four handloom weavers' clusters. The survey was conducted in different handloom clusters of Varanasi. The four selected areas after the survey were selected and Fifty (50) weavers from each cluster were randomly taken for the study. Thus the total sample size was 200. This study was aimed at evaluating the anthropometric measurement of handloom weavers to assess their Body Mass Index to evaluate their physical fitness and Risk Assessment for Musculoskeletal Disorder by Rapid Entire Body Assessment (REBA).The 5th, 50th, and 95th percentile of the various recorded anthropometric dimensions of the handloom weavers were also evaluated. The observations regarding the above anthropometric measurements can be used for redesigning the traditional handloom which will minimize the musculoskeletal disorders of the weavers. The working postures of the handloom weavers during weaving were observed and the score was assigned to each body part by using the REBA score sheet. It was observed during the REBA score assessment that sitting with slight forward bending flexion at the neck and the back with the movement of both hands and legs was acquired by the majority of the handloom weavers while performing the weaving activity.

Keywords: *Environmental factors, Ergonomics, Handloom weavers, Health problems, musculoskeletal problems, Socio-economic conditions*

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1. Introduction

The ergonomic approach of evaluating the present handloom employment status and ergonomic intervention will help in finding some effective solutions. The financial misfortune due to such disorders influences not only the individual but moreover to society also. It is necessary to assess & control occupational health hazards at the workplace of weavers which may cause injury, illness, weakened health, discomfort, and inefficiency in workers of the community. Because of incompatible working circumstances, handloom weavers in textile industries are facing challenges with many work-related musculoskeletal issues related to torment and distress. Many ergonomic problems arise from poorly designed tools, work areas, and repetitive motions. The handloom sector is aimed to generate and provides direct and indirect employment to over 4.3 million people all over India [13]. The predominance of the problems are due to poor ergonomics and designing of workstation and prolonged hours of constant working atmosphere in the carpet industry [2].

The research will focus on how occupational health hazards at the worksite affect handloom weavers and based on findings future recommendations for the corrective measure can be proposed. As occupational health is affordable, accessible, follows equity and contributes to the national economy, the finding of research will help in strategy formulations for handloom weavers; thus the handloom weavers' society can be benefited.

The findings explored through research will be applied for making weavers compatible systems, strengthening the application of high-quality ergonomics, strengthening the demands for high-quality ergonomics by enhancing awareness. Handloom weavers do physical labor beyond their capacity. Hence, Ergonomic interventions will be made in the study regarding the multifactorial genesis of work-related muscular disorders, health problems, and physical conditions of the workplace for sustainable employability to prolong working life. Ergonomics points to ensure that tasks, tools and equipment, facts, figures, content and information, and the conditions and circumstances suit each worker.

The textile and apparel industry is one of the foremost driving sections in the Indian economy. Ergonomics is the scientific and logical application of the standards and strategies that can draw data from several disciplines for the advancement of the system in which an individual plays a significant role. In the garment industry, numerous operations are repetitive in nature and continuous repetition of the work causes musculoskeletal problems and disorders. It has been broadly recognized that awkward and constrained postures result in musculoskeletal disorder on distinctive body locales of seated workers and are a significant component in the emergence of the development of musculoskeletal disorders. Destitute postures have also been found to be related to diminished effectiveness of performance, which is caused by body discomfort resulting from confined and restricted body postures.

Musculoskeletal disorder related to work is a major problem in most occupations. The prevalence, characteristics, and impacts of WMSDs in certain anatomical areas of the body among handloom industry workers in Kerala was determined.. This research was conducted with a modified Nordic Musculoskeletal Questionnaire (NMQ) to assess the prevalence of disorders that occurred. A self-administered questionnaire in regional language was prepared and distributed among 380 full-time handloom workers [19]. The research was conducted to study the dietary status, socio-economic status, and occupational health hazards of the Baluchari Saree weavers of Bishnupur. Sixty-two handloom weavers in the age group between 17-75 years willingly co-operated for the study and thus were selected by the convenient sampling procedure. The evaluation of their nutritional condition exhibited notable pervasiveness of malnutrition (53.22 %) in the weavers of Baluchari Sari [11].

A total of 60 workers were taken for the study from the Lakhimpur district of Assam. The assessment of the working posture of women workers involved in various handloom activities was performed. Data were collected by interview method, photography, video recording, and observation of work practices. The postural assessment was done by using ergonomic tools: RULA and Strain Index. Awkward postures were observed in the handloom workers. The mean RULA score was found highest in weaving activity with 6. 41±0.49 followed by warping, spinning. Strain Index was found highest in the right hand and left hand of weaving activity. The high occupational risk was found in the handloom activities. Therefore, the application of ergonomics would help in reducing postural exertion [4]. The lengthy hours of constant work with inappropriate posture at old designed looms causes the extreme presence of musculoskeletal disorders among carpet weavers. The backrest minimizes some of the trunk or torso loads and assists in impeding vertebral strain. The distinctive sitting postures acquired by the handloom weavers while performing weaving tasks are upright, forward flexed, and side bending. Extended flexion of the spine leads to expansion of intervertebral joint laxity and loss of fluid in the intervertebral discs [5, 8].

Forty women weavers of Samarinda sarongs were investigated to ascertain the widespread and risk component of musculoskeletal disorders (MSDs). In this study, a Nordic body map, anthropometric equipment, and rapid upper limb assessment (RULA) were used to intrigue the MSD extremity, work posture, and anthropometric dimensions of the weavers, respectively [16]. In the present era of advancement and commercialization, the handloom sector is also indicating the changes that the large numbers of women are adopting the weaving activity as their profession. The activity they performed previously during their spare time, has now been transformed to an eight hour job. But, in spite of the increased weaving time spent on weaving looms, the workstation design remains unaltered [16].

In traditional old looms, normally there is no workstation adjustability and adjustment of weaving height is difficult that causes the awkward postures of the upper body. Inappropriately designed hand tools and the kind of the task are the chief causes of awkward postures of wrists and fingers [6]. Handloom is one of the long-established cottage industries in India, especially in West Bengal, where a significant number of rural people are

engaged in weaving. The outcome of the present investigation revealed that highly repetitive works carried out for a long time could increase the intensity of the pain felt and would lead to repetitive strain injuries [3, 9].

The Finnish Institute of Occupational Health (FIOH) identified musculoskeletal disorders as one of the most widespread work-related frailty, emphasizing that despite several parts of the body being involved, the back experiences most of the discomfort [12, 15]. The postures of workers also need to be modified, and corrective measures need to be introduced to minimize the risk of musculoskeletal disorders in the long term [18]. The weaver has often been forced to adopt squatting posture to operate the traditional carpet looms and as the width of the carpet increases and they have to lean forward to complete the task [3].

2. Methodology

2.1 Selection of Sample

The survey was conducted in different handloom clusters i.e. Madanpura, Badi bazaar, Alaipura, Nati Imli, Lallapura, Ramnagar, Lohta, Baragaon, Basani, Ashapur, Bajardiha, Ausanganj, Golgada, Basani, and Saraiya. The four selected areas after the survey were Lallapura, Bajardiha, Ausnganj and Saraiya. Fifty weavers from each cluster were randomly taken for the study. Thus the total sample size was 200.

2.2 Development of the tool

The socio-economic questionnaire was administered to the weavers for the evaluation of their socio-economic status. A thorough investigation of the review of literature helped and enabled the researcher to develop the tool. Care was taken to incorporate all the needed information as decided and a suitable interview schedule was prepared to get relevant information based on the interview.

2.3 Collection of Anthropometric Data

Various anthropometric measurements of handloom weavers such as sitting height, sitting eye height, sitting shoulder height, sitting elbow height, sitting mid-shoulder height, waist height, popliteal height, buttock popliteal height, shoulder breadth, hip breadth, arm reach forward, elbow to elbow, upper limb length, forearm hand length were taken. All subjects were told to wear light clothing without footwear. For taking standing measurements, the subjects were informed and asked to stand upright and facing forward and arms hanging adjacent to the body. To take measurements in sitting position, subjects were asked to sit upright on a chair without the support of armrests, with knees bent on 90 degrees, and the feet kept flat on the surface, facing forward and arms hanging adjacent to the body. The measurements of each handloom weaver were taken three times for maintaining the accuracy in results. The analysis of the data obtained in the present study was done precisely. The 5th, 50th, and 95th percentile values were also calculated to understand and interpret the data. The statistical analysis of each group of data was conducted for the elucidation of the results.

2.4 Risk Assessment for Musculo-skeletal Disorder by Rapid Entire Body Assessment (REBA)

REBA is an ergonomic tool for the assessment of musculoskeletal disorders which uses a structured and organized procedure to assess the whole body postural MSD and risks related to the performance of the tasks. REBA is a single-page worksheet that is used to assess the required or selected body posture, intense and forceful exertions, type of movement, motions, and action, reiteration, and coupling of the body parts during the performance of an activity or task. Posture for risk of work-related musculoskeletal disorder among handloom weavers in Varanasi was assessed by using REBA Scale [14].

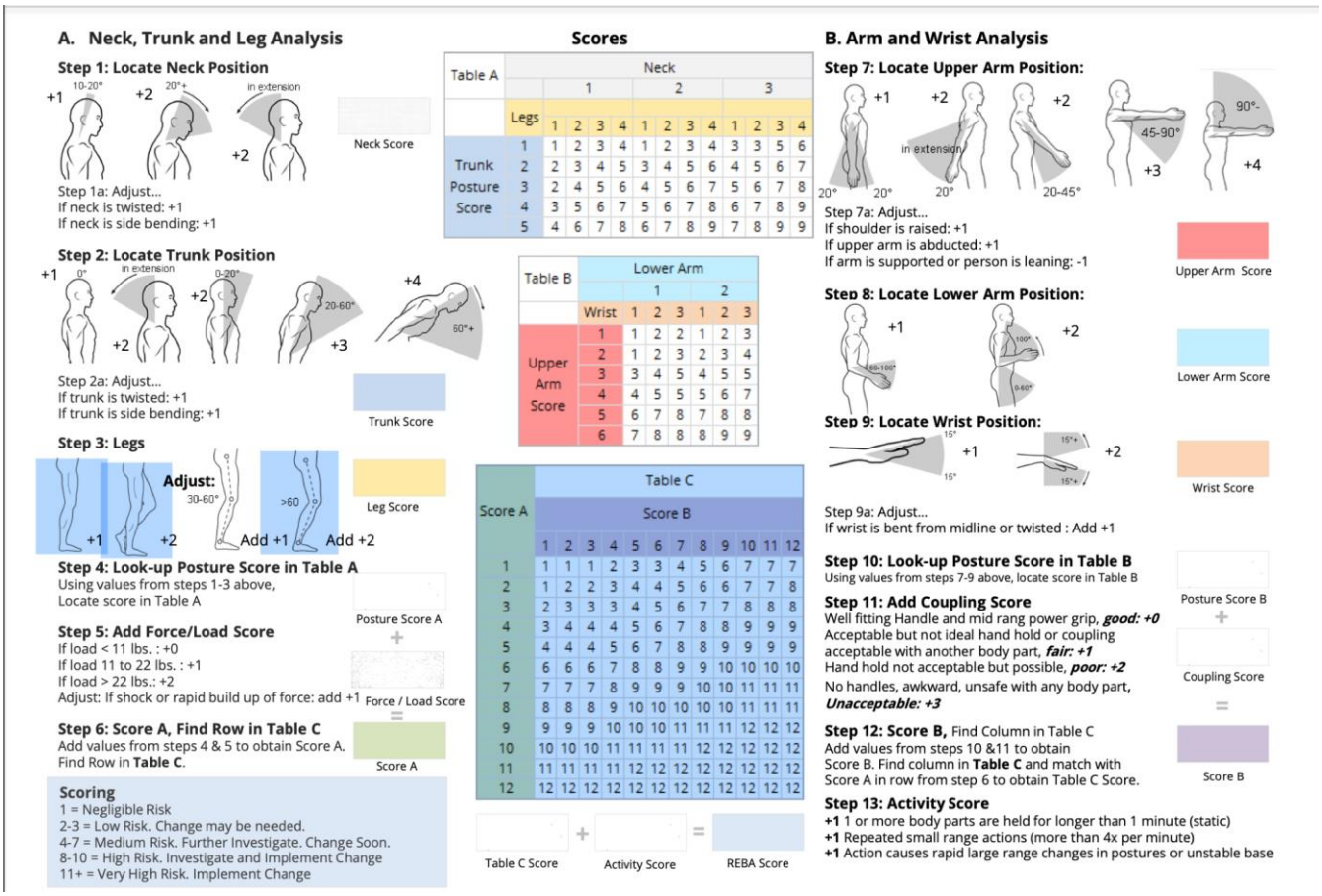

Table 1 - REBA Decision Score

REBA Score	Risk Level
1	Negligible
2-3	Low
4-7	Medium
8-10	High
11-15	Very high

3. Results and Discussion

3.1 Risk Assessment for Musculo-skeletal Disorder by Rapid Entire Body Assessment (REBA)

The working postures of the handloom weavers during weaving were observed and the score was assigned to each body part by using the REBA score sheet. The position of the wrist, neck, lower arm, upper arm, and trunk during the handloom weaving activities was also critically observed for analysis of the posture.

Table 2 - Employee Assessment Worksheet

Body parts	Mean	Standard deviation	Maximum score
Neck	2.60	0.3648	3
Trunk	4.80	0.3678	5
Upper arm	3.40	0.4356	6
Lower arm	1.00	0.0000	2
Wrist	2.00	0.0000	2
Coupling	2.00	0.0000	2
Score B	7.8	0.3657	12
Score C	9.8	0.4323	9
Activity score	1.00	0.0000	1
REBA score	10.8	0.4566	11

Table 2 reveals the REBA score assigned to different body parts of handloom weavers in Varanasi handloom clusters. It showed that in the score a maximum mean score of 4.80 was for the trunk and in the score, B maximum mean score of 3.40 was for the upper arm. The mean for score B which included wrist, lower arm, upper arm, and coupling was higher (mean score 7.80) when compared to score A (mean score 6.74) which included neck, trunk, leg, and force /load score. The mean for score C was 9.80 which after adding the mean of activity score (mean score 1.00) turned to REBA mean score (mean score 10.6.). It was observed during the REBA score assessment that sitting with slight forward bending flexion at the neck and the back with the movement of both hands and legs was acquired by the majority of the handloom weavers while performing the weaving activity.

Postures with elbow flexion of the right hand, abduction, and adduction of the hands, flexion of wrist and pronation of the legs and feet during treadling operations, pronation of hands during beating action and passing shuttle, raised shoulder abduction, and shoulder flexion while weaving were found among the handloom weavers. These all significantly contributed to the musculoskeletal disorders and health hazards of weavers.

A study was conducted to assess the risk of musculoskeletal disorder in handloom weavers of the Durrie unit. The data in their study revealed that the mean REBA score was 11 which indicated a very high level of risk and the mean QEC score for neck, back, and wrist/hand was 17, 31, and 43 respectively were in the very high-risk category and shoulder/arm with mean score 37 in the high-risk category. REBA reported 56.25 percent of weavers were at elevated risk level and 43.75 percent at extremely elevated risk level. QEC also reports 61.25 percent weavers at high and 38.75 percent at the very high-risk category [20].

Table 3: Percentage-wise distribution of the handloom weavers based on REBA score (N = 200)

Action Category	Interpretation	REBA Score (Frequency)	REBA Score (Percentage)
1- Negligible	No change is required	-	-
2-3- Low risk	Change may be needed	-	-
4-7- Medium risk	Further investigation and changes needed	28	14
8-10- High risk	Investigation and implementation of changes	95	47.5
11- Very high risk	Implementation of changes	77	38.5

The REBA action category presented in **Table 3** reveals that a maximum of 47.5 percent of weavers was in action category 4 which ranged between score 8-10 i.e. high risk which signifies directions for investigation and implementation of changes wherever needed, whereas, 38.5 percent of handloom weavers were in action category 5. The score of action category 5 is above 11 i.e. very high risks and this signifies directions to implement change immediately. 28 percent of handloom weavers were found to be in action category 3 which ranged between 4 - 7 i.e medium risk and required further investigation and needed changes.

3.2 Anthropometric measurements of handloom weavers

Various anthropometric measurements of handloom weavers were taken for ergonomic interventions. The observations were analyzed and mean, standard deviation was calculated. The 5th, 50th, and 95th percentile of the various recorded anthropometric dimensions of the handloom weavers was also evaluated.

Table 4 - Anthropometric measurements of handloom weavers in Varanasi District

	Mean	Standard deviation	5th percentile	50th percentile	95th percentile
Sitting height	82.13	3.52	73.00	84.31	88.45
Sitting eye height	68.43	2.98	61.23	72.44	76.90
Sitting shoulder height	51.64	3.76	48.32	55.12	59.89
Sitting mid-shoulder height	39.12	4.12	29.00	42.54	46.97
Sitting elbow height	32.34	3.94	26.12	35.89	38.00
Popliteal height	46.85	4.24	36.89	48.66	56.66
Waist height	24.54	2.25	21.21	25.65	29.90
Shoulder breadth	22.57	3.87	18.00	22.44	26.88
Buttock popliteal height	54.38	3.26	49.54	55.43	63.33
Hip breadth	33.53	4.34	31.00	35.00	43.79
Elbow to elbow	36.34	4.12	30.76	37.54	44.00
Forearm hand length	34.78	2.65	32.00	36.67	38.88
Waist breadth	33.16	3.96	25.43	29.90	38.44
Upper limb length	34.73	2.27	64.56	73.00	75.55

The mean sitting height and sitting eye height were 82.13 and 68.43 respectively, whereas the 5th percentile of sitting height and sitting eye height was 73.00 and 61.23 respectively. The mean sitting shoulder height and sitting mid-shoulder height were 51.64 and 39.12 respectively. The mean popliteal height was 46.85 whereas the mean buttock popliteal height was found to be 54.38. The mean hip breadth, elbow to elbow, forearm hand length, waist breadth, and upper limb length were 33.53, 36.34, 34.78, 33.16, and 34.73 respectively. The observations regarding the above anthropometric measurements can be used for redesigning the traditional handloom which will minimize the musculoskeletal disorders of the weavers.

4. Acknowledgement

I am highly thankful to ICSSR for the sponsorship of the project scheme, IMPRESS under the domain Health and Environment.

5. Conclusion

The hand-woven textiles of India have been recognized and mentioned since ancient times and it is deeply rooted in our lives and traditions. In spite of the fact that it provides and creates employment opportunities for a large number of people, the handloom segment is contemplating as a dusk industry, and there are unavoidable circumstances and discuss of certainty which has given the continual stepping towards the motorization, advancement, and refinement. Still, there are many supporters of handloom for reasons including their logical justifications, beliefs, ethics and principles, sheer affection for handloom products, and economic viewpoint. Many policies and programs were prepared by the government to increase the production, productivity, and GDP through this sector but no attention has been paid to the human component of this sector. Workers, an integral part of this sector, suffer from many health-related hazards due to the nature of this work. Handloom weaving requires long hours of work in static and awkward posture which gradually leads to the risk of work-related musculoskeletal disorder. It has been broadly accepted that inappropriate and severely restricted postures result in musculoskeletal pressure on various body parts of workers in sitting positions and it is the crucial component in the evolution and growth of musculoskeletal problems. Poor postures have also been closely linked with diminished productivity of execution, which is predominantly caused by bodily discomfort which occurs due to limited and restricted postures.

Based on the subjective assessment and responses obtained from the handloom weavers, the major concerning criteria found were related to the following:

- Designing of plank, adjustable height of the seat, depth of the seat and the forward slope/inclination at a different angle and the width of the plank, and the requirement of the backrest.
- The different adjustable seat heights can be prescribed and made based on the data obtained of the popliteal height of the handloom weavers. There should also be an adjustable backrest at the time of weaving as well as at the time of rest during weaving.

- The slope angle of the seat should be adjustable according to the need of the handloom weaver.
- The seat depth should also be modified according to the anthropometric measurements.
- An ergonomically equipped workstation for the weaving allied activities would also be helpful in reducing the exertions which are found during different handloom weaving-related activities.

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