Ergonomic Problems Prevalent in Handloom Units of North East India

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Abstract- Handloom is the mostly widely established cottage industry of North East India (NE) that is most wide spread throughout the region. It employs a large skilled and unskilled workforce and which, in North East, mainly consists of women workers. In the present era of commercialization, handloom sector is also witnessing changes and large number, of women are adopting the weaving activity as their profession. The activity they performed previously during their leisure time, has now been transformed to 8hours job. But, in spite of the increased weaving time spent on loom, the workstation design remains unaltered. The paper reports the ergonomic issues related to weaving practices as adopted in NE, at present and tries to analyze them from the design perspective.

Subjective assessment, direct observation, interview with weavers and the managing bodies were used for determining the work related issues prevailing in the present handloom sector. The study identifies four broader problem areas related to seating, treadling, flying shuttle and cloth rolling operations where design modifications are required to improve work efficiency with reduced manual efforts. Addressing the issues by looking into the ergonomic aspects in existing workstation will have direct impact on quality as well as quantity of outcome thereby, improving the productivity as well as overall occupational wellness.

Index Terms- Handloom, NE India, Women Weavers, Ergonomic Issues, Ergonomic assessment, Ergonomic intervention

I. INTRODUCTION

Handloom is an important cottage industry among developing countries like India, Pakistan, Bangladesh, Iran, Turkey and China where traditional ways of weaving are still significantly practiced. The vast majority of workforce in South Asia is engaged in the informal sectors which also embraces the cottage industries. These industries are an important source of employment, especially for women [1] and human workload assessment would be vital in such industries for improving their working conditions.

It is estimated that there are about 4.60 million handlooms in the world out of which about 3.9 million are in India [2]. Weaving is acknowledged to be one of the oldest surviving crafts in the world. In present era of mechanization and standardization, the handloom sector provides a unique richness of diverse manual skills, representing the cultural and traditional art forms. Handloom industry is one of the largest employments generating industry after agriculture in India and 77.9% of the workforce in this sector is reported to be women. Out of the national figure NE India reports to have the highest number (99%) women weavers [3].

Handloom industry plays a vital role in economic development of the rural masses in the North Eastern States of India. As many small units in handloom sector have taken weaving at a commercial level, more women weavers are associating with weaving as a part time or full time profession. The activities that women performed for their domestic needs during their leisure time, has now been transformed into their professional work. The work hours spent on loom in commercial weaving is quite longer as compared to that of traditional weaving, many a times, even extending beyond 8 hours of work schedule as laid up in the norms [4]. Hence, requirements for commercial purpose are different from that of domestic weaving. But, in-spite of their changing requirements, neither the task schedule nor are the workstations modified. Moreover, no gender specific considerations, related to female built and physiology have been taken into account. The workplace design for traditional handloom remains unchanged which leads to ergonomic issues among women weavers.

Ergonomic approach of assessing the present handloom working status may help in finding some effective solutions. The studies carried out on investigating the ergonomic issues prevalent in carpet industries of Iran, witnessed improvement in quality, productivity and occupational health among the carpet menders [5-8]. In the handloom industry of Western India, study carried out on weavers, on ergonomic issues, suggest difference in prevailing of Musculo Skeletal Disorders (MSD) among males and females[9].This supports the need for ergonomic study in handloom sector of NE India that mainly consists of female weavers, as no gender specific considerations, either anthropometric or physiological, is taken into account in the present design of handloom. Some work has been reported on male weavers regarding posture, repetitiveness, respiratory problems, environmental condition, in different parts of India [9-14] but there is a lack of detailed study on ergonomic issues on women weavers. Some initial studies have been conducted in the handloom industry of NE, addressing working posture related problems faced by the female weavers at the workplace [15].

This paper furthers the study done on the women weavers of NE and tries to figure out, in detail, the ergonomic problems and

relevant scopes of ergonomic intervention to improve the existing loom workstation, aiming at improving their operational easiness and occupational wellbeing. The observations presented in this paper can be regarded as an initiative for improving the working conditions of weavers in the handloom industry of NE, where traditional work practices have been witnessing changes. These changes are accompanied with several health related issues which required to be addressed.

On a casual observation, weaving appears to be a very simple process but in reality it involves diligent processes and stages, involving a number of ergonomic risk factors like awkward posture, high force, repetitiveness, long duration of work and high visual demand. Weaving involves a number of stages, but for study purpose weaving activity has only been considered, as, this is the major task component [3].

Several steps have been undertaken by Government towards promoting the handloom industry, ranging from endorsing handloom products in global market, training facilities for development of weaving skills, motivating the women weavers to take up weaving as profession. Handloom product value depends on quality of production, which mainly depends upon the efficiency of the weavers. Ergonomic interventions would be vital in reducing occupational hazards which increase the efficiency of the weavers, thereby enhancing production.

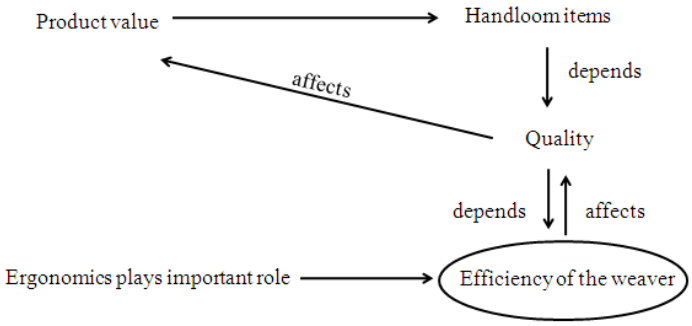

Figure 1 Role of Ergonomics in Handloom

II. RESEARCH ELABORATIONS

To investigate and assess the prevalence of ergonomic issues, cluster of handloom units in NE were visited (both in organized and unorganized sectors) and survey on general working status was conducted. Working on loom involves long static sitting posture where limbs are mostly in repetitive motion leading to stress development on the trunk. A survey was conducted between April 2012 till July 2012, in different handloom units from 10 clusters located in and around Guwahati in Assam; a state of NE India, to find out major work related problems prevailed among the women weavers. A sample of 50 subjects were chosen randomly from both organized (government, semi-government and private agencies) and unorganized (self-help group, small loom clusters which are mainly home based) sectors to understand workstation related design problems prevailed in the existing condition. Handloom units with 8 – 9 hours' work schedule were selected for the study purpose. The workers were all females, apparently healthy without any specific physical problems. The subjects were allowed to use work schedule and duration of work-pause of their own practice. The personal characteristics of the weaves are given in Table 1.

Table I. Personal characteristics of the weavers in the handloom units

Characteristics	Female weavers (n=50) $\overline{X}$ (range)
Age (yrs)	26.82 (18-35)
Yrs of involvement	10.92 (5-20)
Working hours/day	8.57 (8-9)
Literacy	100%

Only one worker at a time was interviewed to avoid loss of productive time. Some of the questions were rephrased to find the consistency to the answers of the weavers.

The study was conducted in two phases, Phase 1 and Phase 2. Phase 1 was further divided into two stages, stage A and stage B, in which stage A consist of self-reported exposure assessment through questionnaire while stage B consist of workplace assessment through checklists. Phase 2 consisted of Video Event Analysis along with the subjective responses of the weavers and management.

Subjective assessment:

Subjective assessment of 50 participants, was done to quantify frequency and severity of pain in different body parts with the help of Self-report Body Discomfort rating Chart [16] along with Borg's 10 point rating scales [17] and Standard Nordic questionnaire [18]. Risk factor of weaving activity was assessed through Quick Exposure Checklist (QEC) [19] and Occupational Repetitive Action (OCRA) checklist [20]. Both QEC and OCRA checklist was used among 33 weavers from 10 units selected randomly from the handloom units.

Direct observation

Direct observation was carried out through video recording and replay event analysis to confirm the findings of the subjective assessment and to further investigate the work problems. 2 hours video recording was done in the field on10 units for 8-9 hours' work schedule (excluding lunch and tea break) and the weaving activity was analyzed in slow motion to find out each problem in details to find out the probable causes of different health problems.

III. RESULTS

The assessment of the present work condition confirmed the prevalence of ergonomic issues by identifying the different health risks and from the analysis of questionnaire and observations, it was found that there were four broader problem areas where specific ergonomic intervention could be suggested. These problem areas were related to seating, treadling, flying shuttle and cloth rolling operation. The general working operation and construct of the loom, in both organized and

unorganized clusters, appear to be same, except the working hours which may be structured or unstructured.

Results of subjective assessment, *Stage A, Phase 1*

Subjective assessment of body pain was done through Self-report Body Discomfort rating Chart based on Borg's 10 point rating scales along with the frequency and severity of occurrence of pain among 50 women weavers for performing weaving operation. From Figure2, it was found that the highest number of weavers reported of having neck, low back and leg pain followed by shoulder and ankle pain. From subjective assessment for frequency of pain presented in Figure 3, it was found that most frequent pains were reported in low back, shoulders, neck and legs.

From subjective assessment for severity of pain presented in Figure 4, it was found that most severe pains were also reported in low back, shoulders, neck, knee and legs.

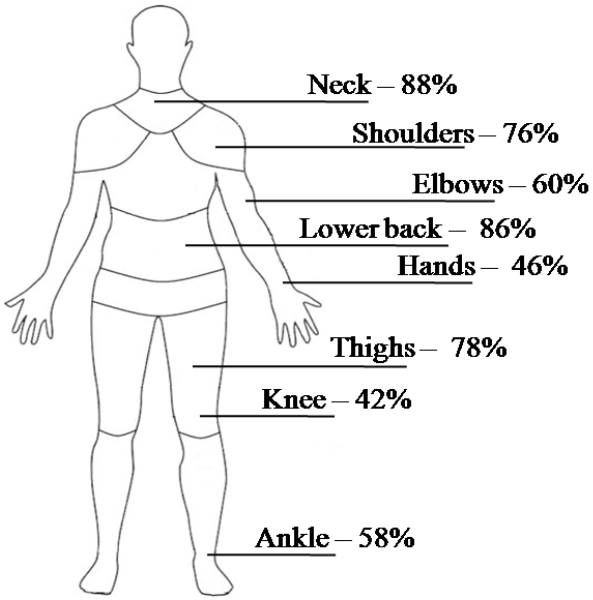

Figure 2. Subjective assessment of pains in different body parts after weaving operation

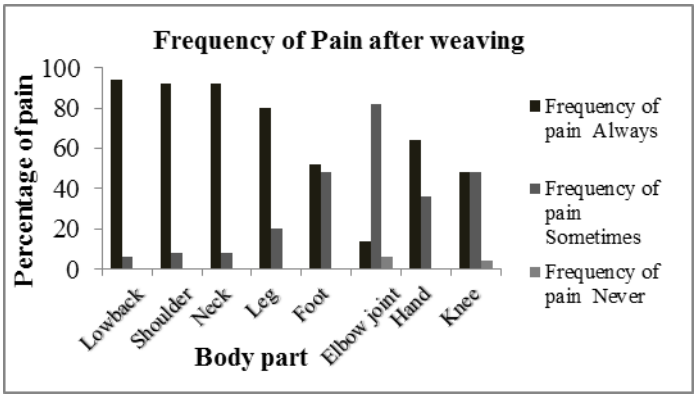

Figure 3. Subjective assessment of Frequency of pain in body parts for weaving operation

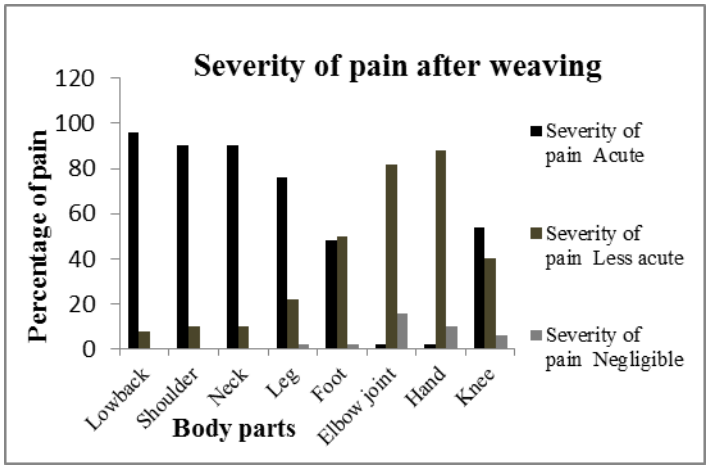

Figure 4. Subjective assessment of Severity of Pain in body parts for weaving operation

A significant percentage of weavers reported of pains after treadle operation, (Figure 2), due to inadequate foot support for ankle and toe which indicates the presence of ergonomic issues and need for ergonomic intervention.

Hence, ergonomic design approach to modify the different components of workstation which interacted with the body parts (namely low back, shoulders, neck and legs) during operation will help to reduce pain.

Risk Assessment by checklists, Stage B, Phase 1

Workers perception and observers assessment was taken into account by both QEC and OCRA checklists. It provided information for understanding the probable causes of the most severe risk factors.

QEC was used over 33 weavers from 10 units. The analysis of weaving operation using QEC gives exposure scores to specific body parts including the back, shoulder/arm, wrist/hand, and neck. The average of total QEC scores for weaving operation was found to be 145 out of 187 giving a percentage score of 77.86% (Table 2) which falls under very high risk and gives an indication that immediate ergonomic intervention are required in the workplace.

Table 2. Recommended QEC % score

The action level from QEC		
Action level	**Intervention recommended**	**QEC % score**
Acceptable risk	Acceptable posture	< 40%
Moderate risk	Further investigation needed; changes may be required	40-49%
High risk	Investigation and changes needed soon	50-69%
Very high risk	Investigation and changes needed immediately	>70%

Table 3. Comparison of derived QEC score of weaving activity with recommended priority scores for different body parts [21]

Priority level for QEC scores [21]					QEC score for weaving activity
Body area	**Low**	**Moderate**	**High**	**Very High**	**Score**
Back (static)	8-14	16-22	24-28	30-40	31
Shoulder/ Arm	10–20	22-30	32-40	42-56	37
Wrist/ Hand	10-20	22-30	32-40	42-56	43
Neck	4-6	8-10	12-14	16-18	17

The individual QEC scores for different body parts have been shown in Table 3obtained scores for different body regions except wrist/hand falls under very high priority levels

Occupational Repetitive Action (OCRA) checklist

OCRA checklist was used to identify the presence of risk factors for the upper limbs and classify the consequent exposure to risk factors. 33 women weavers, with right dexterity, from 10 handloom units having same working hours were selected for the study purpose. The results of the study are presented in Table 4.

Table 4. Recommended and obtained OCRA checklist score for weaving operation

OCRA Checklist	Area	Risk	Checklist score of weaving activity
Upto to 7.5	Green	Acceptable	33.6
7.6 - 11	Yellow	Borderline or Very Low	
11.1 – 14.0	Low Red	Low	
14.1- 22.5	Average Red	Average	
≥22.6	Very red or Violet	High	

From OCRA checklist, it was found that weaving activity falls under very high risk zone. For performing weaving task both the limbs are involved in two different activities. Right limb does shuttle operation and left beats the reed frame. The activity of the two arms are different but adding all the scores separately for two limbs (right and left) and multiplying with multiplier, gives same score for both the limbs.

***Video Event Analyses, Phase** 2*

Phase 2 was based on direct observation method which verifies the findings of subjective assessment and helped to further investigate the problems in detail where in-depth observational study of video recording was conducted to analyze the weaving task. It helped in having better insight of the situation, important for identifying the possible areas of ergonomic intervention to solve occupational health problems. Finally, four major problem areas related to seating, treadling, shuttling and cloth rolling operations were identified (Figure 5).

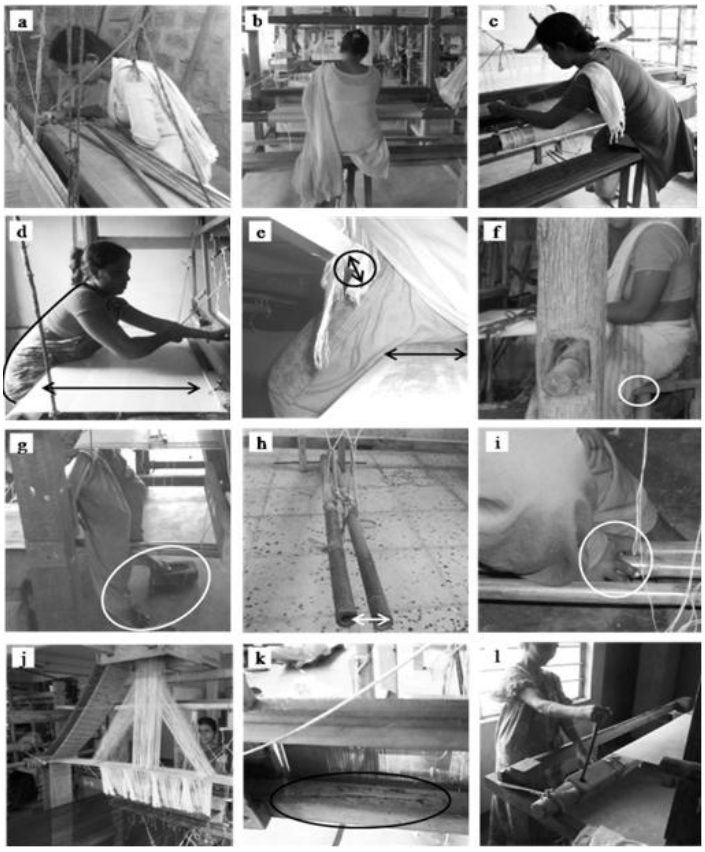

Figure 5. Some observations of video analysis method – a) Forward bending posture, b) Upright sitting posture, c) Side bending posture, d) Forward stretching posture, e) Lack of clearance space between thigh and cloth beam along with improper plank width for sitting, f) Digging of posterior thigh muscle by the hard edge of the plank, g) High seat height leading to improper support for foot, h) Insufficient gap between the two treadles, i) Small and slippery treadle surface made of bamboo sticks, j) Introduction of jacquard system enhancing force requirement for treadling, k) Dented surface of race increasing the force required to push the shuttle over it and l) Adjustment of warp beam by loosening and tightening after getting out of the seat

Details of the observational study through video recording analysis are summarized in Table 5.

Table 5. Findings of an in-depth observational study through video analysis

Problems	Findings/ Observations
Seating related	Weaving involves highly inspection job, where the weavers spend more than 8 hours job schedule in a narrow plank of about 13-15cm(Fig. 5e). The weavers were found to adopt different types of posture continuously and repetitively for performing weaving(Fig. 5a-d). Above all this circumstances, there is no backrest to relax during rest pauses.
	Anterior part of the thigh muscle hit the cloth beam with the upward movement of the legs for oscillatory treadle operation, as there exists no clearance space(Fig. 5e).
	Hard edge of the plank digs posterior thigh muscles with downward movement of legs while treadling(Fig. 5f). The seat height does not take into consideration the popliteal height of the women weavers and in almost every handloom unit, it was found that the foot only partially reach the ground or keep dangling in air(Fig. 5g).
Treadling related	The gap between two treadle is only about 6 to 8 cm which results single leg to operate both the treadle(Fig. 5h).
	Treadles made from thin bamboos which turns smooth and slippery due to regular use, gives minimum foot support, resulting pressure development, in ankle and toe with operational force(Fig. 5i).
	The present way of treadle operation requires moderate force but, it involves high repetition, requiring 94.67 ± 13.59(rpm), leading to development of muscular fatigue of Rectus femoris and Bicep femoris muscles. Treadling activity makes the thigh repetitively hit against the seat edge, which digs into the posterior thigh muscle(Fig. 5f).
	With introduction of Jacquard, more force is required to push the treadle downwards, as additional tension force is developed(Fig. 5j).
Shuttling related	6.67 ± 1.39kg pulling force is needed for shuttle operation with a repetition of 94.67± 13.59 rpm constantly for 10 to 15 minutes leading to the development of fatigue in Trapezius muscles. Due to the rough dented surface of the race, more force is required to operate the shuttle(Fig. 5k).
	Pulling force required for beating operation of reed frame involves highly repetitive activity involving 94.67± 13.59 rpm.
Warp and cloth beam related	Cloth rolling is a tiring exercise which involves many steps and have to be done after every 20- 30 minute interval. At first, the person has to get out of the seat and go to other side of the loom. The roll is then required to be unlocked followed by tightening and adjusting the cloth roll. The beam is relocked which is followed by returning and getting on to the seat. In order to avoid this whole process, they lean forward and maintain this posture during weaving, as long as possible, leading to development of severe back pain(Fig. 5l).
Organizational factors related	With increase price of raw materials, there is a heavy challenge for the survival of the industry, as a result the weavers are paid per work basis. In order to finish task in single spell the weavers spend long hours in the loom to earn more; this result in the development of multilevel occupational health problems.

IV. DISCUSSION

The findings of the study through subjective assessment of body pain, checklist analysis and direct observation suggest that there is a high prevalence of ergonomic risk factor related to the present handloom workstation in the weaving units suggesting that ergonomic intervention is require in the present work situation.

The poor seat design in the present workstation coupled with repetitive treadling operation, affects both anterior and posterior side of the thigh muscles. No thigh clearance space is been observed in the handloom units which aggravates with oscillatory treadle operation. Treadling is highly recurring activity, involving 94.67 ± 13.59 repetitions per minute. The vertical leg movement for oscillatory treadle operation, led to

frequent hitting of the anterior part of the thigh with cloth beam. Performing this type of activity for prolonged time may develop edema or hematoma in the quadriceps muscle [22]. It may also develop pressure on fascia lata, cutaneous nerves and veins of the thigh [23]. Hard edge of the plank, along with raised plank height, leads to the development of pressure, on posterior thigh muscle. Muscle effort and localized pressure result in a relatively short time physiological responses of muscle fatigue, impeded blood circulation and venous blood pooling resulting in edema at the ankle and feet. This situation exacerbates with small foot support space for treadling due to the bamboo treadle, leading to more pressure in the ankle and toe. With the introduction of Jacquard, the load on the cervical spine, due to constant flexion for motif formation, gradually decreases. But, an additional tension develops because of jacquard, pulling the warp thread upward and an extra force is required for using the treadle, thereby increasing the pressure on leg muscle.

Different sitting postures that is forward flexed, upright and side bending, are adopted by the weavers while performing weaving task. Prolonged flexion of the spine leads to increase intervertebral joint laxity and fluid loss in the intervertebral discs [24,25]. Studies suggest that flexed sitting posture results in extension of upper cervical and flexion of lower cervical spine [26]. Due to motif formation and for inspection work, the weavers develop flexed posture while for constant weaving they maintain upright posture which results in isometric contraction of Hamstring muscle [27]. The condition of flexed forward leaning posture is aggravated with poor rolling mechanism of cloth and warp beam. In order to avoid the effort needed for rolling operation, the weavers lean forward and maintain this posture as long as it is possible to weave which leads to the development of severe back pain.

To counteract the negative effect of the adopted posture during weaving operation, the backrest would be required for back muscle support during rest pauses. Seat with any backrest inclination reduces intra-discal pressure [28,29] which increases lumbar lordosis and reduces low back pain [30]. Backrest reduces load on the seat which eventually reduces stress on the spinal and paraspinal structure [8].Backrest can be provided so that the user can use it whenever required [31]. In a similar study it was found, backrest reduces some of the trunk loads and helps to prevent vertebral strain [32,33].

Flying shuttle involves highly repetitive activity, involving 94.67± 13.59 repetitions per minute with a pulling force of 6.67 ± 1.39kg. Ergonomic intervention may reduce the frictional force between the shuttle and surface of the race which will be very effective in reducing the force as repetition cannot be hampered otherwise it will affect production. The findings of the study will be helpful in identifying the areas where ergonomic intervention is required for the weavers. Paying attention to the occupational health and safety issues prevalent in this sector will have noticeable impact on national handloom production, socio-economic condition of the weavers, thereby improving their quality of life. The study underlines the needs for further work regarding ergonomic design implementations in the present loom workstations, along with the gender specific requirements.

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