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Ergonomic Assessment of Activities Performed by Female Weavers

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A B S T R A C T

Weavers work long hours in very small spaces with minimum ventilation and low lighting levels with awkward postures. Hence the present study was taken up to find out the prevalence of Muscle Fatigue Analysis (MFA) among female weavers. An experimental cum observational research design was conducted on different activities performed by the female weavers in Koyyalagudem village of Nalgonda district, Telangana. ECNC Rodgers Muscle Fatigue Analysis online calculator was used to assess the fatigue accumulation in the muscles of different body parts of weavers. Almost all left body region and right body region in warp yarn preparation, pay folding, tieing of yarn, weft yarn preparation, heddle loom and pit loom was found to be at high risk level. So the activity is not accepted and immediate action has to be taken to reduce risk factors.

Introduction

The Indian handloom industry is the second-largest employment provider for rural population in India with almost 43 lakh weavers. A significant portion of State workforce in Telangana is dependent on handloom industry for employment in which women participation is quite high as weaving is a family profession. Mostly women are involved in reeling, winding, and weaving which are labour intensive activities.

The structure of handloom weaving industry consists of both unorganized sector and an organized sector. The unorganized sector comprises of independent weavers, master weavers and weavers working under them. The organized sector consists of the apex society popularly known as Co-optex, the weavers' societies and the weavers working under them.

The weavers working under master weavers can be grouped under two heads, namely, weavers with own looms and loom less

weavers. The weavers working under the master weavers with own looms almost always work in their homes, but they weave the fabrics according to the specification of master weavers on their own looms.

The weavers work on their loom from morning till evening without adopting ergonomic principles which may lead to work risk. Work risk could be caused by many things, such as workplace and workers' postures. Work risk arises because of unhealthy workplaces, such as vibrations, excessive force and contact pressure. Poor work posture and repetitive movement could create work risk too. Both of them could cause musculoskeletal disorders. MSD provoke loss of work time, injured workforce, and increased labor costs. MSD could lead to injuries and disorders of the muscles, tendon or others.

Choobineh *et al.* (2003) stated that more than three- fourth per cent of the respondents have adopted deviated postures indifferent body parts, including upper arm, lower arm, neck, trunk and leg. In vertical looms there is no leg clearance which forces the weavers to work in a cross legged or fixed leg posture.

Poorly designed workstations, looms and hand tools and deviated body postures from a neutral position were harmful to the weavers. In horizontal looms, weavers sit on the looms which cause awkward postures in neck, back and lower extremities. In traditional looms, generally there is no work station adjustability and adjustment of weaving height is difficult which causes the awkward postures of the upper body. Poorly designed hand tools and the nature of the task are the main causes of awkward postures of wrists and fingers (Choobineh*et al*., 2004).

Gallagher (2005) reviewed the physical capacities and musculoskeletal complaints related with work in unusual posture or restricted posture. The respondents adopted unusual or restricted postures which is strongly associated with significantly higher rates of musculoskeletal disorders compared to workers not adopting these awkward postures in epidemiology studies. Some research studies suggested a relationship with elongated exposures augmented the musculoskeletal complaints. Physical strength and psychophysical lifting capacity varied significantly when unusual or restricted postures were adopted with lower lifting capacities observed in the kneeling, squatting and lying postures.

The weaver has often been forced to adopt squatting posture to operate the traditional carpet looms and as the width of the carpet increase and they have to lean forward to complete the task (Banerjee and Gangopadhyay, 2010).

However the present study was undertaken to assess the musculo-skeletal disorders experienced by women weavers due to their involvement in various weaving related activities.

Materials and Methods

Experimental cum observational research design was selected for conducting the study on different types of loomsused in Koyyalagudem village of Nalgonda district. Videos were taken for each activity to analyze Muscle Fatigue Analysis (MFA) of weavers. ECNC Rodgers Muscle Fatigue Analysis online calculator was used to assess the fatigue accumulation in the muscles of different body parts of weavers.

The Muscle Fatigue Analysis (MFA) was proposed by Rodgers as a means to assess the amount of fatigue that accumulates in muscles during various work patterns within 5 minutes

of work. The hypothesis was that a rapidly fatiguing muscle is more susceptible to injury and inflammation. With this in mind, if fatigue can be minimized, so should injuries and illnesses of the active muscles. This method for job analysis is most appropriate to evaluate the risk for fatigue accumulation in tasks that are performed for an hour or more and where awkward postures or frequent exertions are present. Based on the risk of fatigue, a Priority for Change can be assigned to the task (Rodgers, 1992).

Results and Discussion

Results of the study were presented below in detail on different activities of handloom weavers.

Floor Charka/Ratnam): WarpYarn Preparation

Floor charkha is one of the oldest known forms of the spinning wheel. The charkha works similarly to the great wheel, with a drive wheel being turned by hand, while the yarn is spun off the tip of the spindle. The floor charkha and the great wheel closely resemble each other. With both, the spinning must stop in order to wind the yarn onto the spindle.

Dimensions

Ratnam diameter: 2.8 inches
Length: 3 ft
Pole height: 1.9 inches
Pole to pole length: 1.5 inches

From Table 1, Muscle Fatigue Analysis showed that in warp yarn preparation activity, majority of the female weaver body parts i.e., neck, back, right and left side shoulder, arms, hand/wrist and ankles/feet were found to be at very high risk. Right and left legs/knees were found to be with high risk. Therefore activity is not accepted and immediate change is required.

Chitka Asu: Pay folding

ChitkaAsu is in triangular shape as threads and designs are drawn on this shape. Tying is done when required as per the design and the threads are then dyed in selected colours. Once dried and untied, the dyed silk threads are rolled into spindles. The spindles are used appropriately in looms and the saree is woven.

As a part of the weaving process, thread has to be wound from a single peg on one side to 40 pegs on the other, on a four-foot structure. The thread has to be wound through each of the 40 pegs, using the single peg as a pivot.The process, known as Asu, is laborious and painful as weavers were left with aching shoulders and elbows.

Dimensions

Width: 3’3”
Height: 1’10”
Length: 4’10”
Asukoyala: 39 no.

In pay folding activity majority of the female weavers’ body parts i.e., neck, back, shoulders, arms, hand/wrist, legs/knees, ankles/feet were found to have very high risk.

Tieing

For weaving Ikat, a design is first chosen and the yarn tied at suitable spots after being tightly wrapped (at the handloom park, strips from old cycle rubber tubes were used to tie the yarn) in such a way that the tied spot resists the dye.

If a pattern includes more than one colour, the procedure is repeated a number of times. This may be done on individual yarns or bundles. Each time a new colour is added, the bound yarn is opened, ready for another round of wrapping. This gives Ikat its unique feathered look. It's extremely time consuming.

In tieing of yarn activity, majority of female weavers were found withvery high risk factor in different body parts i.e., neck, back, right side of the hand/wrist and legs/knees whereas low risk was found in both right side of the shoulder and moderate risk was found in left side of the shoulder. While high risk factor was found in left side of the wrist/hand.

Spinning wheel/ Pante – Weft yarn preparation

Spinning wheel is a device on to which yarn is wounded by rotating the wheel with the left hand and simultaneously guiding by right hand so as to get winding intact.

Dimensions

Height of the pante: 2 ft
Height of the middle 4 sticks: 1.1”
Rod to Rod distance: 4”

In weft yarn preparation activity, most of the female weaver opined that this activity has very high risk priority in neck, left shoulder, right arm, left arm, right and left wrist/hand, left legs/knee, right and left ankle/feet. So the activity cannot be accepted as an easy task and need to take immediate action.

While preparing the yarnin different ways i.e., warp yarn preparation, pay folding, tieing of yarn and weft yarn preparation, most of the female weavers have very high risk in their body parts, so the activity is not accepted and immediate action has to be taken to reduce risk factors.

Heddle loom

A heddle is an integral part of a loom. Each thread in the warp passes through a heddle, which is used to separate the warp threads for the passage of the weft. The typical heddle is made of cord or wire, and is suspended on a shaft of a loom. Each heddle has an eye in the center where the warp is threaded through. As there is one heddle for each thread of the warp, there can be near a thousand heddles used for fine or wide warps. A hand woven tea-towel will generally have between 300 and 400 warp threads, and thus use many heddles.It also offers a lot in terms of patterning to an experienced weaver through hand manipulation of the warp and weft. One rigid heddle, can be used for two-shaft weaving using yarns that are generally thicker than those used by shaft looms. By adding another heddle, the weaver can use thinner yarns and weave more intricate patterns using pick-up sticks and hand manipulation techniques.

Dimensions

Length: 7 feet
Width: 8 feet
Loom to loom width: 5.5 feet
Loom height from floor: 3 feet
Loom rolling: 4 feet
End of the loom rod: 3.9 inches

From Table 5, Muscle Fatigue Analysis shown that in Heddle loom activity majority of the female weaver body parts i.e., neck, back, right side shoulder, arms, hand/wrist, legs/knees, ankles/feet and left side shoulder, arms, ankles/feet were found to be very high risk. Left side wrist/hand and legs/knees were found to be high.

Pit loom

Pit loom is a type of loom which is fitted in a pit where the workers weave different types of fabrics through the use of pedals, and normally the base of pit loom is stronger than handloom and can go without using latex. In working, it simulates the handloom; the only difference is its size and height. It is called as pit loom because of the pit below the loom which is used for the shedding operation. The space or gap between the two layers of the warp threads is called shed. A shed is produced by means of healds or harnesses. The warps are maintained in tension between two beams, in between healds are used with help of two levers; these healds are connected with two paddles situated inside the pit, which are used for the shedding. Wefts are inserted manually inside the shed. The warp threads are divided into two layers or parts one above the other, for the passage of the shuttle with a pick of weft. It is used mainly for producing thin flat-weave fabrics. These fabrics do not have a pile and they are often reversible.

On a horizontal ground loom, the warp would be strung between two rows of pegs. The weaver would have to lean over in order to work, so pit looms were developed, with the warp strung over a pit, to let the weaver have his or her legs positioned below and leveled with the loom.

Pit loom weaving is considered to be a better weaving as the fabric woven retains the character of the yarn and fabric due to the proximity to the ground. The ground absorbs the tension and speed and make the fabric more breathable which is the reason for being less dense or stiff.

Dimensions

Length: 16.9 feet
Width: 8 feet
Loom to loom width: 5.5 feet
Loom height: 5.1 feet

Table.1

Table.1 Assessment of muscle fatigue analysis in warp yarn preparation (Ratnam/Charka)

Body Parts	Score			Priority for change
	Effort	Duration	Frequency	
Neck	4	2	4	Very High
Shoulder (R)	3	2	4	Very High
Shoulder (L)	3	2	3	Very High
Back	4	4	1	Very High
Arms (R)	3	3	2	Very High
Arms (L)	4	3	2	Very High
Wrist/Hand (R)	3	3	2	Very High
Wrist/Hand (L)	4	2	1	Very High
Legs/Knees (R)	3	2	1	High
Legs/Knees (L)	4	2	1	High
Ankles/Feet (R)	2	4	2	Very High
Ankles/Feet (L)	2	4	1	Very High

Table.2 Assessment of muscle fatigue analysis in pay folding (ChitkaAsu)

Body Parts	Score			Priority for change
	Effort	Duration	Frequency	
Neck	4	3	3	Very High
Shoulder (R)	4	4	3	Very High
Shoulder (L)	4	3	3	Very High
Back	4	3	2	Very High
Arms (R)	4	3	2	Very High
Arms (L)	4	3	2	Very High
Wrist/Hand (R)	4	3	2	Very High
Wrist/Hand (L)	3	2	4	Very High
Legs/Knees (R)	4	2	3	Very High
Legs/Knees (L)	4	3	3	Very High
Ankles/Feet (R)	4	3	3	Very High
Ankles/Feet (L)	4	4	1	Very High

Table.3 Assessment of muscle fatigue analysis in tieing of yarn

Body Parts	Score			Level of Risk
	Effort	Duration	Frequency	
Neck	4	4	2	Very High
Shoulder (R)	1	2	1	Low
Shoulder (L)	1	2	2	Moderate
Back	2	4	2	Very High
Arms (R)	4	2	1	Very High
Arms (L)	4	3	2	Very High
Wrist/Hand (R)	4	2	1	Very High
Wrist/Hand (L)	3	2	2	High
Legs/Knees (R)	4	3	1	Very High
Legs/Knees (L)	4	3	1	Very High
Ankles/Feet (R)	4	3	1	Very High
Ankles/Feet (L)	4	3	1	Very High

Table.4 Assessment of muscle fatigue analysis in weft yarn preparation (Spinning wheel/ Panthe)

Body Parts	Score			Priority for change
	Effort	Duration	Frequency	
Neck	3	2	4	Very High
Shoulder (R)	3	2	2	High
Shoulder (L)	3	2	3	Very High
Back	3	2	1	High
Arms (R)	3	3	2	Very High
Arms (L)	4	3	2	Very High
Wrist/Hand (R)	3	3	2	Very High
Wrist/Hand (L)	4	2	1	Very High
Legs/Knees (R)	3	2	1	High
Legs/Knees (L)	4	2	1	Very High
Ankles/Feet (R)	3	3	2	Very High
Ankles/Feet (L)	2	4	1	Very High

Table.5 Assessment of muscle fatigue analysis in weaving activity (Heddle Loom)

Body Parts	Score			Priority for change
	Effort	Duration	Frequency	
Neck	3	3	2	Very High
Shoulder (R)	2	4	2	Very High
Shoulder (L)	2	4	2	Very High
Back	3	4	2	Very High
Arms (R)	2	4	1	Very High
Arms (L)	3	3	1	Very High
Wrist/Hand (R)	4	2	2	Very High
Wrist/Hand (L)	3	2	1	High
Legs/Knees (R)	4	3	1	Very High
Legs/Knees (L)	3	2	2	High
Ankles/Feet (R)	4	2	3	Very High
Ankles/Feet (L)	4	2	3	Very High

Table.6 Assessment of muscle fatigue analysis in weaving activity (Pit loom)

Body Parts	Score			Priority for change
	Effort	Duration	Frequency	
Neck	4	2	4	Very High
Shoulder (R)	3	2	4	Very High
Shoulder (L)	4	2	3	Very High
Back	4	4	1	Very High
Arms (R)	4	3	2	Very High
Arms (L)	4	2	2	Very High
Wrist/Hand (R)	4	3	2	Very High
Wrist/Hand (L)	4	2	1	Very High
Legs/Knees (R)	3	2	1	High
Legs/Knees (L)	3	2	1	High
Ankles/Feet (R)	2	4	2	Very High
Ankles/Feet (L)	2	4	1	Very High

Table 7. Assessment of muscle fatigue analysis in weaving activity (Standing Loom)

Body Parts	Score			Priority for change
	Effort	Duration	Frequency	
Neck	2	3	2	Moderate
Shoulder (R)	2	3	2	Moderate
Shoulder (L)	2	3	2	Moderate
Back	2	3	1	Moderate
Arms (R)	2	2	1	Low
Arms (L)	2	2	1	Low
Wrist/Hand (R)	2	2	2	Moderate
Wrist/Hand (L)	2	2	1	Moderate
Legs/Knees (R)	2	3	1	Moderate
Legs/Knees (L)	2	2	2	Moderate
Ankles/Feet (R)	2	2	1	Low
Ankles/Feet (L)	2	2	1	Low

- Pit loom height: 3 feet
- Loom rolling: 4 feet
- End of the loom rod: 3.9 inches

In pit loom activity majority of the female weavers' body parts i.e., neck, back, right and left side of the shoulders, arms, hand/wrist, ankles/feet were found to be very high risk. Right and Left side of legs/knees were found to be high.

Therefore, in female weavers while weaving the heddle loom and pit loom activity most of them have very high risk in their body parts, so the activity is not accepted and immediate action has to be taken to reduce risk factors.

Standing type loom (Developed)

Standing type loom is also same as heddle loom, but it differs in size i.e., height, width and length. It is smaller than heddle loom. It is used for weaving scarfs, kerchief and small fabrics. Each thread in the warp passes through a healds, which is used to separate the warp threads for the passage of the weft. The typical heddle is made of cord or wire, and is suspended on a shaft of a loom. Each heddle has an eye in the center where the warp is threaded through.

Dimensions

- Width of the loom (which is used to weave furnishing material, apparel and sarees)
  - 60 inches without the side beams

used to hold the loom parts
- 65 inches with the side beams used to hold the loom parts

- Length of the Loom – 4 metres (approximately). It may vary depending on the space available in the weavers' house.
- Depth of the Pit (Gunta) used to fix the loom – 2 – 2.6 feet depending on the height of the user.
- Length of the shuttle used to hold weft yarn – 13 inches.

In standing type loom, majority of female weavers were found to be moderate in different body parts i.e., neck, back, right and left side of the shoulders, hand/wrist and legs/knees whereas low risk was found in both right and left side of arms and ankles/feet. While in standing type loom, most of the female weaver opined that the weaving activity has low risk priority, so the activity is accepted and no need to take any action.

From the study it was concluded that almost all left body region and right body region in warp yarn preparation, pay folding, tieing of yarn, weft yarn preparation, heddle loom and pit loom was found to be at high risk level. Female weavers focus on the use of right and left body region, especially right and left shoulder, arms, ankles/feet hand and hand/wrist to do the activity so right and left body region have more load in this activity which is leading to high risk level. This implies that charkha, chitkaasu and spinning wheel require to be mechanized by attaching a motor so as to reduce the muscle fatigue. A stool with wheels can be designed to sit at chitkaasu for doing pay folding activity comfortably. When three types of looms were compared, standing loom was found to be with moderate risk which can be improvised by increasing the width of it and attaching a motor to it so as to weave sarees, dupattas and fabric. Thus standing loom is suggested over pitloom and heddle loom.

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