AN ERGONOMIC APPROACH TO DESIGN HAND TOOL FOR TEXTILE PRINTING SECTOR

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ABSTRACT:
This study was conducted in Textile Printing industry to determine the occurrence of upper limb problems associated with hand too design, investigate the existing hand tools currently used in textile printing, and design hand tool based on anthropometric dimensions and ergonomic principles. This study consisted of two phases. In the first phase, 100 printing workers from Jaipur areas participated. A questionnaire consisting of personal details, Nordic Questionnaire for upper limbs and a table for anthropometric dimensions of hand were used to collect the required data. In the design phase, the study focused on designing the hand squeegee used in screen printing. The musculoskeletal disorders are the most common work-related health problems in India, affecting thousands of workers. Typically, musculoskeletal disorders affect the back, neck, shoulders and upper limbs; less often they affect the lower limbs. If ergonomic philosophy can be included, then the risk factors of occupational injuries will be compressed. On the basis of first phase, a feedback survey conducted to ergonomically design of new hand tool and known the satisfaction and dissatisfaction level of the workers.

Keywords: *Textile Printing, Musculoskeletal disorders (MSDs), Ergonomic principles.*

1. Introduction:

Ergonomics is the well-regulated come out suddenly troubled in the matter of the fellow of interactions midst humans and second elements of a system, and the profession that applies theory, Principles, data and methods to design in order to optimize human well-being and overall system performance. In a lavish middle of property occupations, refuse tools are primary tools.
A first undertaking of these industries is the high percentage of injuries that occur annually.
In different occupations, several of the mischievous causes of work-related disorders and diseases are linked to the use of hand tools. Ergonomically well-designed hand tools may reduce the risk of occupational injuries of the upper limbs. They except for adjust comfortable work for the workers and give high production rate . Anthropometry is the review of the intelligence and abilities of the human Company. It plays an memorable proprietorship in ergonomics, architecture, clothing design and industrial design. Making function of the household living in different countries differ from each other. Body sphere of the kinsfolk living in different countries differ from each other. It occurs allowing for regarding m in different countries exhibit difference in nutrition, life style, ethnicity etc.

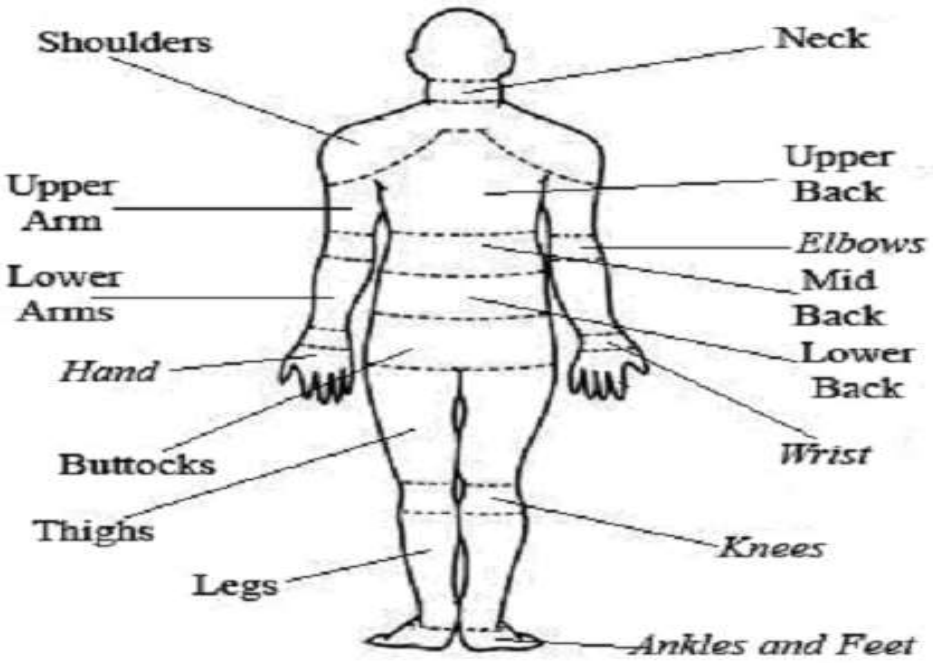

Figure 1 Body Parts of People

Textile printing was famous in Europe, via the Islamic world, from about the 12th century, and was generally used. Textile printing was introduced into England in 1676 by a French refugee who opened works, in that year, on the banks of the Thames near Richmond. In Germany, too, textile printing was in all probably well-established before it spread to England, towards the end of the 17th century, the district of Augsburg was celebrated for its printed linens, a reputation not likely to have been built up had the industry been introduced later than 1676. The development of screen-printing began in Japan in the middle of the 17th century. The Japanese technique was taken to France where modern flat screen printing was developed, initially using silk fabric stretched over a wooden frame .

1.1 Printing Process:

The fabric was obtained in grey state by the buyer that was further sent for processing to the local dealers. The processing included scouring of fabric with Sodium bicarbonate and detergent to remove the grease and dirt particles from the fabric followed by bleaching using oxidizing bleach to impart whiteness. The fabrics were then dried and dispatched to the printing units. It was then cut into the required length as per the article to be printed i.e. for sari a length ranged between 5.5 or 6 meters was needed. The printing table was coated with wax and the fabric was placed on it. The coating was done either monthly or bimonthly, depending on the production. On the other hand printing paste was prepared by the dye master wherein mixing was carried out manually in most of the units. After the printing final finishing touches are given at the edges where dye paste had not penetrated were accepted out physically with the help of a sponge dipped in dye paste. The fabric was then dried on the table for two to three hours followed by hanging on the cords for complete drying in open air some of the units also used hot tables for drying the fabric.

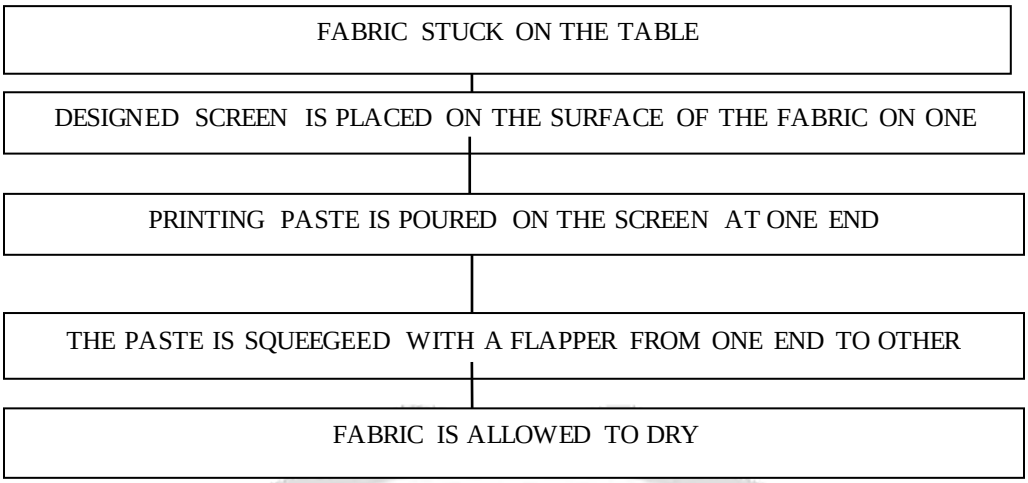

Figure2 Screen printing processes

2. Materials and Methods:

This study consisted of two phases, which are explained separately.

2.1 Phase 1:Field study

In this phase, survey questionnaire was used for further study.15 textile printing units in Sanganer and Bagru, in Jaipur, were selected and 100 male workers were taken into consideration in this study. All the 100 workers involved in screen-printing were interviewed and consequently questionnaires were filled. Based on the videos, photographs, personal interviews and filled survey questionnaires, problems of the workers in textile printing were identified. The questionnaire consisted of three parts including; (a) personal details, (b) Nordic Musculoskeletal Questionnaire for upper limbs and (c) anthropometric dimensions of
hand.

2.2. Phase 2: hand tool design:

In the design phase, based on the results of the first phase, designing screen printing hand squeegee, for designing handle shape and length, the hand anthropometric database and printing practice were the basic considerations.

Ergonomics Design Principles:

Physical factors taken into consideration in developing new hand tool are described below:

- The major muscles which flex the fingers and generate grip force are located in the forearm. These muscles have long tendons which span the wrist joint. Thus, the gripping capability of the fingers is affected by the position of the wrist. According to Tichauer' suggestion, continued use of hand tools with the wrist in a bent position can cause inflammation, chronic pain, and possible permanent injury both to the synovial sheaths protecting the tendons of the wrist and to the median nerve passing through the wrist [7].
- For greatest comfort of use and least stress, the tool handle should be oriented so that, while working, the hand and the forearm should be aligned to avoid ulnar or radial deviation. Deviations of the wrist from the neutral position under repetitive load can lead to a variety of cumulative trauma-disorders as well as decreased performance, since the shape of the tool handle will affect the posture used to hold it, the shape of the handle is a primary factor which can be used to reduce or eliminate fatigue in the user.
- Recesses such as finger grooves should not be provided because of the wide variations in finger anthropometry in the population. In particular, a person with large fingers may create

compressive forces on the lateral surfaces of the fingers, which are areas abundant in superficial nerves and veins.

- If a tool has a short handle that does not span the breadth of the palm, high forces are created at the centre of the palm. Thus, the tool handle should be designed to extend beyond the hand when gripped.
- Sharp edges and corners may cause cuts, bruises, or abrasions. Hence, one should seek to eliminate such hazards by rounding edges and corners with as large a radius as possible [8].

3. Results:

3.1 Phase 1:

On the basis of survey result we concluded that more no of workers suffering from various symptoms disorder in textile printing industry. Below table1 shows that percentage of workers suffers from symptoms.

Table1 Perception of workers

Symptoms	No. of Workers	Percentage of Workers (%)
Headache and tired	58	61
Stiffness in neck or upper back	57	60
Pain in low back	72	75.7
Pain in shoulder	74	77.8
Pain in fore-arm	61	64.3
Soreness in elbow	65	68.4
Stiffness in knee	67	70.5
Soreness in arms	63	66.3
Pain, numbness, cramping or falling asleep of hand/wrist	59	62.1
Stiffness in finger	68	71.5

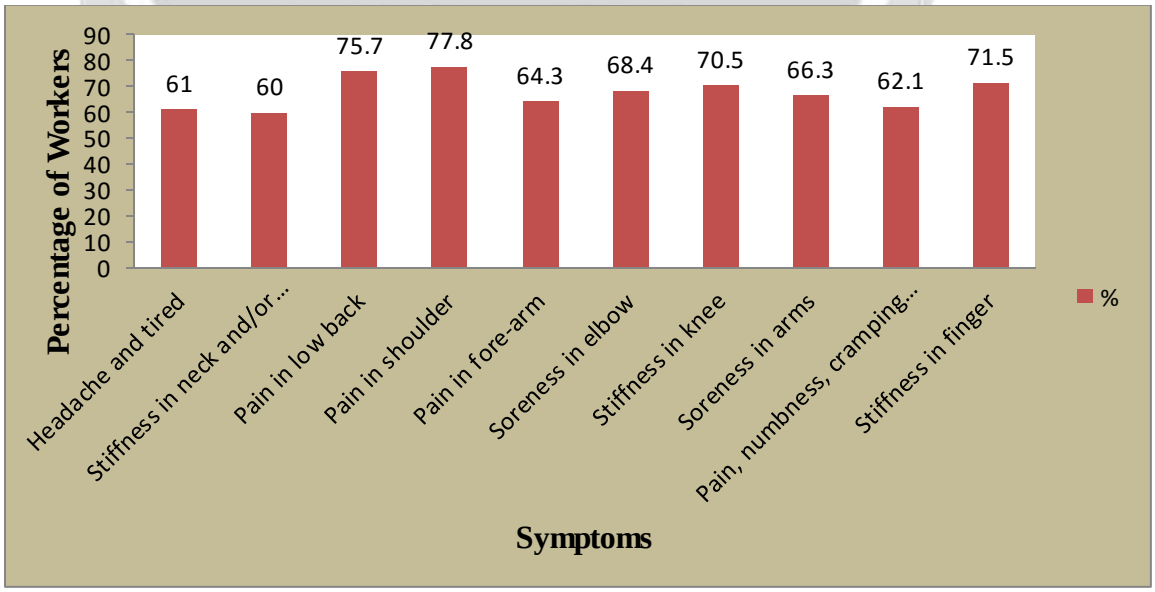

Figure 3 Bar chart for various body pains

The above graph shows the percentage of workers suffering from different problems 61 % of the workers were found to have problem of headache and tiredness, 60% complained of stiffness of neck

and upper back, 75.7 % suffered from pain in lower back. Largest number of workers i.e. 77.8% suffered from pain in shoulder. 64.3% of workers suffered from pain in forearm. 68.4% suffered from soreness in elbow and 70.5% of workers suffered from stiffness in knee.66.3% suffered from the soreness in arms and 62.1% suffered from cramping and numbness,71.5% suffered from stiffness in finger.

Survey results shows that 66% workers want to improvement in working conditions, Other result shows that more than 59% of workers do not satisfied with their working environments. Nearly 44% of workers work on screen printing table more than 20 minutes in single instants. 40% workers want to design the hand squeegee with handlebar because of they are not comfortable with exiting tools. Most of workers suffer from various symptoms problems which is not good for long time, so that workers want to some design improvements in their exiting hand tool. Hence our aim is to design a hand-tool in such a way that it would minimise discomfort and pain.

3.2 Phase 2:

Based on ergonomics hand tool design principles, and hand anthropometric dimensions of the printing workers, prototypes for screen printing hand tool were developed. The details of design process are presented below.

In order to minimize the Muskulestcal disorder of screen- printing workers. It also increases the productivity of the firms and decreases the various body pains such as low back pain, soreness in arms, and pain in shoulder. We have to design hand tool for screen-printing workers so that, calculating all the body dimensions of the workers in 5%, 50%, 95%. We have to design the hand tool only for Jaipur resigns of workers anthropometry data considering.

Table 2. Percentile of Anthropometry Data

Parameter	**5thPercentile**	**50th Percentile**	**95th Percentile**
Hand length(C_1)	16.745	18.65	20
Upper arms(C_2)	24.075	26.45	29.85
Lower arms(C_3)	24	26	29
Shoulders width(C_4)	38.03	42	45
Standing height(C_5)	159.06	169	174.765
Hand grip length (C_6)	7	9	11.255
Grip diameter(inner) (C_7)	3	3.6	5
Grip diameter(outer) (C_8)	5.915	7.5	10.51
Palm length (C_9)	8.83	11	12.6
Palm Width(C_{10})	4.5	10.05	12
Thumb length (C_{11})	4.545	6.85	7.97
Thumb breadth (C_{12})	2	2.3	3
Fist length (C_{13})	7.715	9	10.485
Wrist breadth (C_{14})	5.3	6.25	7.185

Wrist thickness (C_{15})	3	3.65	5
Wrist circumference(C_{16})	15	16.5	18.255
Chest breadth(C_{17})	26.575	29.75	34
Waist height(Leg) (C_{18})	90.3	101	104
Fingers Length(C_{19})	6.215	7.9	9.5
Hand breadth(4 fing.) (C_{20})	7.8	8.95	10
Shoulders Height(C_{21})	136	145	153.8

3.3 Design Parameters of Hand Tool:

Hand tools are used in most of industrial works to enhance the physical capabilities of workers. However, poor design and excessive use of hand tools were found to be the major cause of work-related injuries associated with cumulative trauma disorder. Deteriorate on workers' health and their suffering are inaccessible whilst economic lost from worker remedy and compensation is enormous. To prevent and alleviate cumulative trauma disorder, appropriate tools designed and used for workers and their tasks are needed. In order to design a hand tool, one needs to calculate the necessary dimensions of a hand tool which in turn depend upon comfort conditions for a worker, Studies focusing the overall comfort of the worker. Data significant for a hand tool are discussed below:

- **Task Considerations**
- **User Considerations**
- **Grip and Handle Considerations**

On the basis of above consideration, we were design the hand squeegee for screen printing workers. Using triangular method and anthropometry data, calculate handlebar length for designing of new hand tool. The total length of handle bar was found that 97.02 cm. Grip diameter taken at 5^{th} percentile such as 3 cm, and all the data taken average of 5^{th} and 95^{th} percentile.

3.4 Dimension of Existing Hand Tool:

In screen-printing, a hand tool which is used to pull and push the colour on screen-bed is called hand squeegee. The dimensions of hand squeegee are given in cm as below:

Work table breadth = 150 cm

Screen-bed dimensions = 128 x 147 cm

Hand squeegee dimensions = 130 x 12 cm

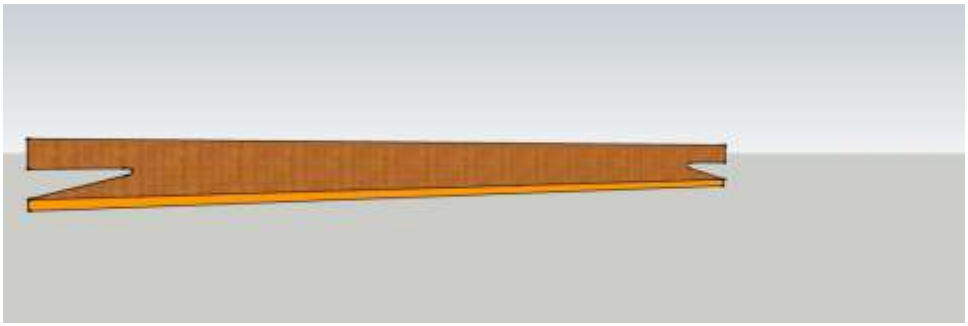

Figure 4 existing hand tools

3.5 Physical Model Preparation:

Based on the anthropometric data taken average of 5^{th} and 95^{th} percentile considering the design of physical model, all the data given below which is use:

Handle length= 11 cm, Grip diameter = 3cm, Width between both handlebar = 41.5cm, total length of handlebar = 97.02 cm

Figure 5 Physical model of hand tool

3.6 Prototype testing results:

After Ergonomically design of hand squeegee, we have to generate survey feedback questionnaire and gone to firm or industries, work has to done by workers two to three days after that taken feedback of the workers. The sample size of survey is 40.

Table2. Perception of workers about symptoms

Particulars	**No. of Workers**	**Percentage of Workers**
Headache and tired	12	30
Stiffness in neck or upper back	7	18
Pain in low back	11	28
Pain in shoulder	9	22

Pain in forearm	7	18
Soreness in elbow	8	20
Stiffness in knee	9	23
Soreness in arms	12	30
Pain, cramping of hand/wrist	6	15
Stiffness in finger	10	25

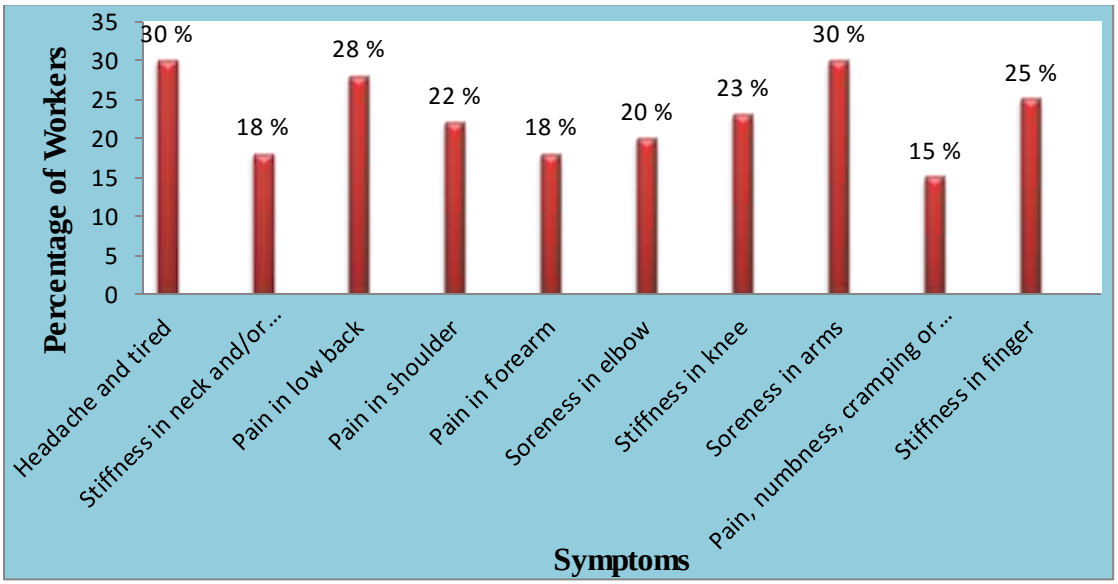

Figure 6 Bar chart shows percentage of workers

The above graph shows the percentage of workers suffering from different problems 30 % of the workers were found to have problem of headache and tiredness, 18% complained of stiffness of neck and upper back, 28 % suffered from pain in lower back. 22% suffered from pain in shoulder. 18% of workers suffered from pain in forearm. 20% suffered from soreness in elbow and 23% of workers suffered from stiffness in knee.30% suffered from the soreness in arms and 15% suffered from cramping and numbness,25% suffered from stiffness in finger.

4. Conclusion:

This study showed that upper limbs MSDs occurred at a high rate among textile printing. From the survey feedback, it could be concluded that, new hand tools caused the concentration of contact stress on the palm of hand to be eliminated. The designed handles were perceived more comfortable than conventional ones. The new ergonomically designed screen printing hand tools were found to be applicable and acceptable for the screen printing workers. Results shows that shoulder pain was the big problem of screen printing workers which have been reduced to 22% from 77.8%,pain in low back have been reduced 28% from 75.7%. However, further study is needed to make appropriate revisions to the ergonomically designed tools based on quantitative measures of musculoskeletal loading.

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