Ergonomic Evaluation and Workstation Redesign of Tambat Ali Artisans in India

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Abstract: In a country like India, where over 90% of the $700-billion retail market is part of the unorganised sector, this large section of society is highly susceptible to detrimental health effects. This study determined the prevalence of Musculoskeletal Disorder (MSD) symptoms in coppersmiths and provided possible interventions for an ergonomic workstation. The research used Five-point Body Part Discomfort Scale to evaluate physical pain, and Rapid Entire Body Assessment (REBA) and the Quick Exposure Checklist (QEC) to assess working postures. The results revealed that the Matharkaam activity causes chronic discomfort due to awkward postures. Insights from the study were used to model an ergonomic and sustainable alternative to the workstation that would help reduce MSDs.

Practical Implications: This paper ergonomically analyses the current working process and workstation of the Tambat Ali Artisans, and findings indicate that they are at a high risk of work-related musculoskeletal disorders. The insights have been channelled towards proposing a feasible workstation design, that can improve their postural difficulties.

Keywords: Coppersmiths; Design Intervention; Musculoskeletal Disorders; QEC; REBA; Tambat Ali

1. Introduction

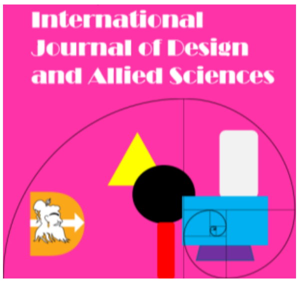
The persistent increase of unorganized labour force has become a common feature of the world economy over the last few years. India has more than 75% of its workforce employed in the informal or unorganized sector (Kuhn et al. 2018). Numerous issues have been plaguing the daily life of the workers in this sector. Handicraft artisans are often grouped under the unorganized sector because they use home-based production systems. Given the significance of this sector to the economy, it is essential that these workers' working conditions improve in order to boost productivity.

This paper is based on the Tambat Ali artisans from Pune, India, who are a part of the unorganized sector of the Indian Economy. In Marathi, the word 'tamba' means copper, hence a Tambat is a coppersmith, which is how the name 'Tambat Ali' came about.

The Tambat Ali coppersmiths live in clusters that have been in existence for generations. Due to the severe physical effort and low income return nature of the occupation, just about 30 workshops operate today. These workshops are built outside their houses in the heart of the city.

They work on a unique process of aestheticism of copper vessels called ‘Matharkaam’. It is the process of making small mosaic-like indentations on a vessel. It is done to improve the vessel's strength and aesthetic appeal. It requires uncomfortable postures to execute and is done with tools and equipment that are designed specifically for the task. The Matharkaam stage is the most crucial, and it is what distinguishes these goods from other copper vessels.

Kalkis (2015) suggested that Musculoskeletal Disorders (MSD), including lower back pain, arm and neck muscle or tendon sprains and joint diseases, have a noticeable impact on workers efficiency and productivity, which affects not only individual production levels but also national production levels 3. An increase in MSDs will cause an inevitable decrease in the number of artisans in the Tambat Ali community and will further add to the community’s despair.



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Despite the alarming ergonomic discomfort and the importance of the unorganised sector in our economy, there has been very little work done towards ergonomic studies on the Tambat Ali artisans. Furthermore, no subsequent design interventions that would help improve these conditions have been proposed.

Thus, the objective of this study is:

1) To understand and analyse the current working process and existing workstation of the Tambat Ali Artisans
2) To determine the prevalence of MSDs in the artisans caused due to the Matharkaam process
3) To generate insights and pain points that can be translated into a feasible design intervention
4) To design an ergonomically and economically feasible workplace solution that helps reduce the severity of MSDs among the artisans.

2. Research Methodology

Work in this research went through 5 main steps:

1) Study design and selection of subjects
2) Method selection
3) Data collection
4) Data analysis
5) Results validation and suggested interventions.

This section will elaborate on each of these steps.

2.1. Study Design and Selection of Subjects

The first step included literature review and semi-structured interviews with field experts that led to the structural model used as the base for this work. A cross-sectional study was conducted in Kasba Peth, Pune, Maharashtra on 33 male copper artisans. This selection was reasoned to:

1) Their engagement in the Matharkaam aspect of making copper vessels
2) Their age
3) Their experience

The selected participants were between the ages of 45 and 72 and have been working in the profession for over 25 years.

2.2. Method Selection

Method selection decisions were made keeping in mind the objective at hand. The methods that were finalized to be carried out to calculate and evaluate the postures, and the presence and significance of MSDs amongst the artisans are discussed. The Rapid Entire Body Assessment (REBA) (Hignett and McAtamney 1999) was used to analyse the postures susceptible to MSD's while performing myriad tasks. For every activity, each part of the body was scored. These scores were noted on scale.

The second method used was the Quick Exposure Checklist (QEC) (Li and Buckle 1998). QEC is designed to assess the changes in exposure to MSD risk factors of various postures. The artisans' responses in various sections were calculated to get the final score and determine the prevalence of MSD's (David et al. 2008).

The Body Part Discomfort Scale (Corlett and Bishop 1976) was also used to take into consideration every individual subject's direct opinion of discomfort at different body parts. The assessment of Body Discomfort was undertaken in seven different body parts, namely - wrist/fingers, lower arm, upper arm, shoulder blades, back, lower back and legs. The artisans were allowed to rank between 0-5 (0= No Pain, 5= Worst or Bad Pain).

2.3. Data Collection

Data collection went through three main paths: structured interviews, observation and artisan analysis. Two rounds of interviews took place:

1) Introductory Inquiry
2) Exploratory Inquiry

Anthropometric dimensions were measured using a measuring tape. These measurements include- standing height, sitting height, shoulder width, upper arm length, hips breadth (sitting), shoulder height (sitting) and eye height (sitting). These dimensions were selected keeping in mind our objective of designing an ergonomically improved workspace solution.

2.4. Data Analysis

In step 2.4, the collected data was compiled together to draw together the big picture of the coppersmith's work environment and to study the prevalence of MSDs present amongst the artisans.

2.5. Results Validation and Suggested Interventions

Finally, this step included drawing inference from the pain points and conclusion from the data analysis to generate an ergonomic intervention that would improve the lives of the Tambat Ali Coppersmiths by reducing their chronic exposure to MSDs.

3. Results

The overarching method of producing copper vessels is depicted in **Figure 1**. As you can see, Matharkaam is a part of this process.

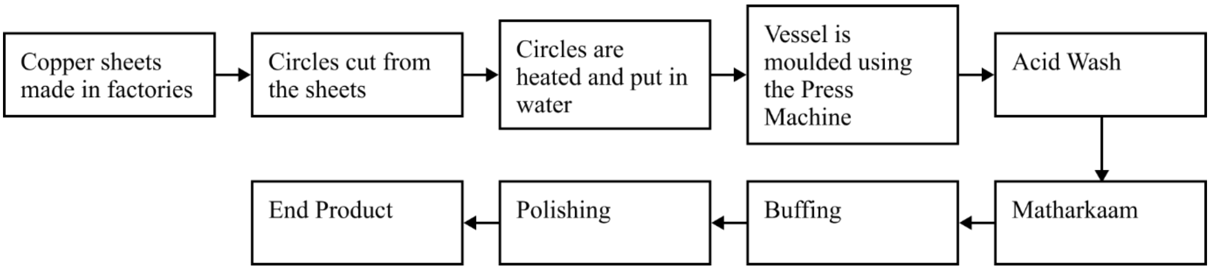

Figure 1. Diagram depicting the process of making a vessel.

Figure 2 depicts the Matharkaam workstation. The artisan sits on a 'A' shaped wooden seat, also known as a 'khod,' which is kept on the floor. The seat is made of seasoned wood, and the two legs are approximately at a 60-degree angle to one another. It is not cushioned and the artisan sits on it for hours.

The hole in the centre of the 'A' structure allows for the inclusion of an iron bar anvil to support the vessels. The iron bar anvils are tailored to the vessel's curves. The protruding portion of the anvil is called the 'Mukh'. It's long, wide, and bent at an angle. The vessel is placed in an inverted position on the Mukh and is then pounded on with hammers to achieve the indentations. When hammering, the iron bar anvils do not have wrist support, causing the wrists to be bent at an angle. The size and shape of the hammerhead create different indentations on the vessel. The hammerheads differ depending on the location of the indentations on the vessel.

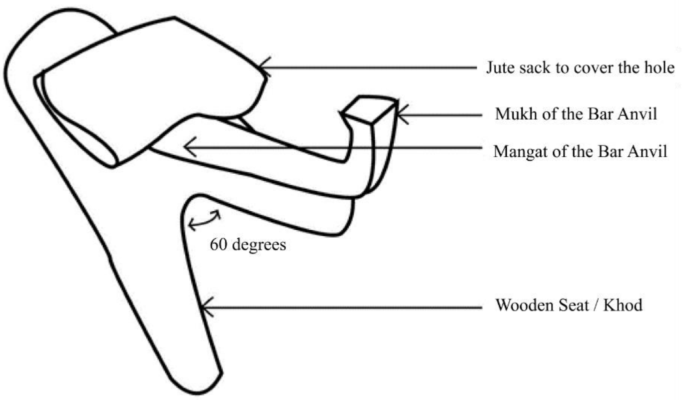

Figure 2. Diagram depicting seating set-up of the artisan.

Additionally, it was noted that the workshops were congested and dimly-lit. The workshops were constructed in an area measuring approximately 500 sq. meters to 750 sq. meters. For some artisans, the verandah area outside their houses was used as their workshop. It was used to store raw materials, tools, machinery, copper vessels and to perform the various activities in the copper vessel-making process as illustrated in **Fig 1**. The artisans used extremely basic personal protective equipment, such as a rag of cloth or a glove in one hand while working.

Table 1 shows details of artisans' working habits that participated in the study. From the questionnaire it was found that the artisans' workforce was 100% male. The questionnaire further enquired about their working hours, contribution to the vessel-making process, and asked them to rate their postural stress.

It was discovered that artisans worked long days with just two brief breaks for lunch and tea. 54.5 % of artisans worked more than 8 hours a day, 24.2 % worked 6 to 8 hours a day, and 21.2 % worked part-time until 4 hours a day. 66.7 % of the artisans surveyed said a holiday of one day from the week was inadequate to recover from the previous week's work, while 33.3 % said one day was adequate.

Table 1. Details of the artisan's studied (n = 33)

Age (years)			Weekly Working Hours (Hours)	
Mean	**SD**	**Range**	**Mean**	**SD**
55	7.8	45 - 72	43.2	11.5

SD = Standard Deviation

3.1. Results Validation and Suggested Interventions

The Tambat Ali artisans were studied closely in order to determine their work posture and recognise ergonomic risk factors for Cumulative Stress Disorders. The following are the factors that have been identified:

3.1.1. Force

The Matharkaam step, which requires constant hammering, necessitates a lot of muscle strength. The hammerheads are made of iron and have a lead and iron alloyed hitting surface. They weigh up to 2kg. Excessive force causes muscles to contract faster than they should, causing strain on muscles, tendons, and joints.

3.1.2. Repetition

The Tambat Ali artisans work on the same vessel for hours at a time, creating repetitive indentations across the entire surface area. This causes distress on the wrist.

3.1.3. Static Posture

The two most common examples of static posture in Tambat Ali artisans are prolonged periods of awkwardly positioned sitting and constant hammer gripping. This causes increased back and leg problems.

3.1.4. Awkward/Extreme Posture

Figure 3 depicts a standard working posture for performing Matharkaam. The artisan's back is arched, and his neck is bent, putting strain on tendons and other supporting tissues.

Figure 3. Matharkaam activity and stick diagram of the posture.

3.1.5. Environmental Factors

The artisans who worked in the workshops had mounted light bulbs and tube lights, but the workshops were dimly lit due to their limited size and congested layout. Natural lighting was used by artists who worked on their verandas outside their homes. The noise levels were also high due to the heavy hammering.

3.2. Postural Analysis

Table 2 represents the scores from REBA and QEC. The analysis of the artisan's pose while performing Matharkaam was found to be high-risk, requiring immediate intervention as indicated by the REBA assessment (Table 2). Table 2 also indicates the high levels of vibration and work tension involved in the Matharkaam process. According to the QEC assessment, the back, leg, wrists / fingers, and neck were found to be the most exposed areas of the body. These assessments indicate that the working postures of coppersmiths while performing Matharkaam are the reason for their musculoskeletal complaints and body pain.

Table 2. Postural Stress of Matharkaam Activity

Postural Stress	**REBA***			**QEC***						
	Score A	**Score B**	**Final Score**	**Back**	**Shoulder**	**Wrist/Hand**	**Neck**	**Vibration**	**Work Pace**	**Stress**
Score	7	3	9	27.1	32.5	41.7	18	7.5	2.2	9.5
Interpretation	High Risk. Investigate and Implement Change			High	High	Very High	Very High	High	Low	High

*Rapid Entire Body Assessment (REBA) (n = 33), Quick Exposure Checklist (QEC) (n = 5)

Table 3 shows the prevalence of postural problems among the artisans surveyed using the Body Part Discomfort Scale. It further validated that the artisans' wrists/fingers, back, lower back and legs suffered the most discomfort.

Table 3. Body part discomfort score for different body segments among Matharkaam artisans

Body Part	**Discomfort Scale** (n=35) (Percentage of Artisan Participants)						**Mode Score** (Highest Frequency Score)
	0	**1**	**2**	**3**	**4**	**5**	
Wrists / Fingers	0%	20%	5.7%	14.3%	28.6%	31.4%	**5**, Worst Pain
Lower Arm	0%	11.4%	22.9%	31.4%	28.6%	5.7%	**3**, Moderate Pain
Upper Arm	2.9%	22.9%	28.6%	34.3%	5.7%	5.7%	**3**, Moderate Pain
Shoulder Blades	0%	20%	20%	25.7%	25.7%	8.6%	**3.5**, Moderate Pain
Back	2.9%	2.9%	11.4%	17.1%	28.6%	37.1%	**5**, Worst Pain
Lower Back	0%	5.7%	17.1%	17.1%	20%	40%	**5**, Worst Pain
Legs	2.9%	22.9%	11.4%	22.9%	14.3%	25.7%	**5**, Worst Pain

The questionnaire study revealed that 9.1 % of artisans surveyed said that their lower body went numb in 15 minutes, 42.4 % in 15 to 30 minutes, 27.3 % in 30 to 45 minutes, 12.1 % in 45 minutes or more, and 9.1 % said their lower body didn't go numb at all. The most common complaints from the artisans were body pains and hammering noises. This may be due to the fact that these matharkaam artisans have to perform a considerable amount of rigorous hammering work which may lead to discomfort.

3.3. Anthropometric Dimensions

Table 4 displays the Anthropometric measurements of the artisans taken with a plastic measuring tape.

Table 4. Determinant Criteria for adjustable workstation (n = 33)

Features	**Anthropometric Measure**	**Criteria Determinant (percentile)**	**Anthropometric Dimension (±SD)**
Seat Surface Height	Sitting Height	50th Percentile + 25mm for Protective Footwear	**870 (±47.3) mm**
	Eye Height (sitting)		**700 (±76.5) mm**
Seat Width	Shoulder Width	95th Percentile	**630 (±73.8) mm**
	Hips Breadth (sitting)		**830 (±89.3) mm**

The 50th percentile was selected as the determinant criterion for the dimensions and proportions of the new revamped workstation's seat surface height to account for the normal body type and have a more inclusive solution. The 95th percentile was used to calculate the seat width so that larger people could use the workstation comfortably.

4. Workstation Redesign

The matharkaam workstation was redesigned based on the needs of the artisans as identified in our research. We also reviewed the guidelines provided by Bhattacharya and McGlothlin (2012) in Occupational Safety (Appendix B: Ergonomics Checklist, Repetitive Hand Task: Ergonomic Design) to help us understand ideal workstation requirements.

4.1. Concept and Features

The plan for redesign of the Matharkaam workstation is shown in **Figure 4**. The workstation will function like a foldable table and will rest on top of the artisan's lap. This will allow them to reach the copper vessel without hunching over their workstation, thus reducing shoulder, back, and neck strain. Because of the elevation in the workstation, the artisan wouldn't have to over bend to use and perform the precision work. The workstation's height is measured to be 2 inches below elbow height.

The workstation's top is divided into two sections: (1) the main workstation in the "E" shape, and (2) the table's top. The artisan will be able to increase the angle of the main workstation to get it closer to the artisan using two support rods that can be hooked into various ridges along the table top. This offers additional support and elevation for the artisan. The workstation table's legs will be removable. There is a compartment provided in the back that will accommodate the removable legs. This will enable the artisans to close the workstation and store it compactly off the work floor, saving space on the work floor. The artisans can use the workstation while sitting on a cushion or a rug on the floor when it is assembled and in use.

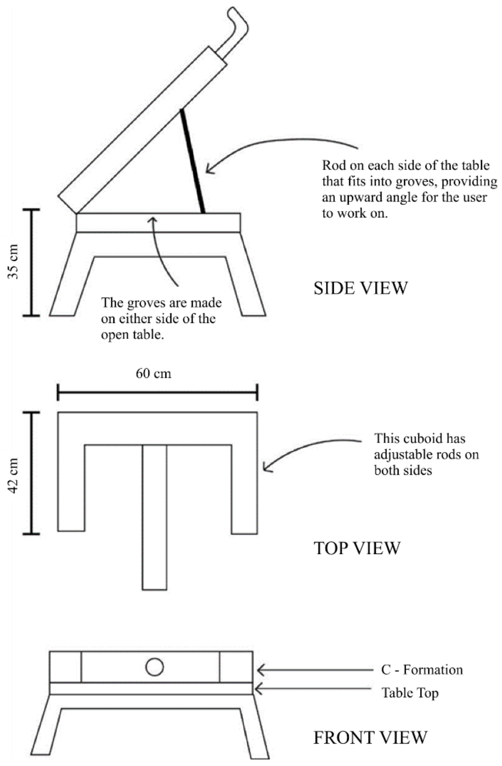

Figure 4. Sketch of the prototype.

4.2. Prototype

Figure 5 shows a cardboard prototype of the proposed workstation. It was made in line with the measurements mentioned in **Figure 4**.

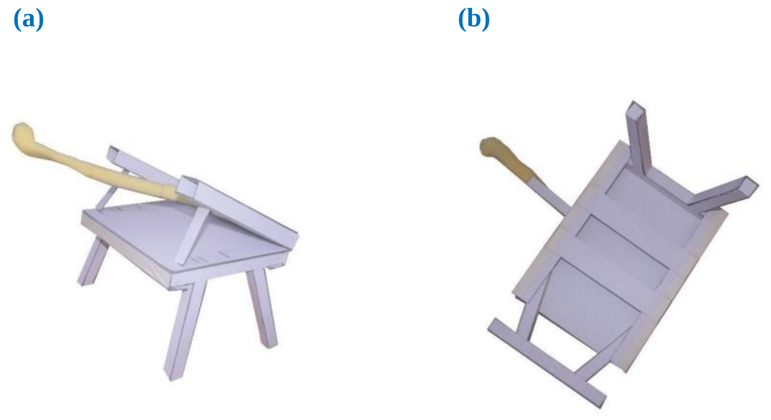

Figure 5. Cardboard model for design understanding: (a) isometric view with raised main workstation on support rods hooked along the table top, and (b) bottom view with 2 types of inserted removable leg of the prototype

4.3. Improvements

To perform their work, the artisans must adapt and use a variety of hammers and iron bar anvils to hammer and shape their copper vessels. To accommodate this, the new workstation is designed in a 'E' shape to support their lower arms and elbows with the help of support handles on both sides. They provide protection by minimising wrist flexion and deviation. In contrast to the conventional workstation, the artisan will pivot their hammering action from the elbows rather than the wrist. As a result, the wrists, arms, and shoulders are relieved of tension.

A hole in the centre of the main workstation is provided to fix the various iron bar anvils. The required iron bar anvil needs to be attached into the workstation by fastening it into the hole on the main workstation using its threaded ends. This will help give a steady footing to the iron bar anvils. The main workstation can be adjusted to an angle that enables the 'Mukh' to be 6 inches above the elbow height to give easy access to the artisan to efficiently perform the precision work.

The height and the adjustable angle of the workstation makes it possible for the artisan to reach the 'Mukh' within 15 inches of their body. These distances were highlighted by Bhattacharya & McGlothlin (2012) to be optimal visual distances that will reduce stress and tension over the arms and shoulders for precision work. Since the workstation is adjustable, it is also able to cater to artisans of varying body types to fit and use the workstation efficiently.

Figure 6 depicts the Tambat Ali artisans' working pose after using the revamped workstation and Table 5 depicts the REBA score for the redesigned working pose. We can observe that the new working posture's REBA score has been reduced to 6 from a 9. This categorizes the new workstation as a medium risk. We can thus estimate that our design intervention is expected to alleviate postural stress involved in Matharkaam. To further reduce the risk, further redesigning can be employed based on the user feedback. Usability testing is yet to be conducted for design validation.

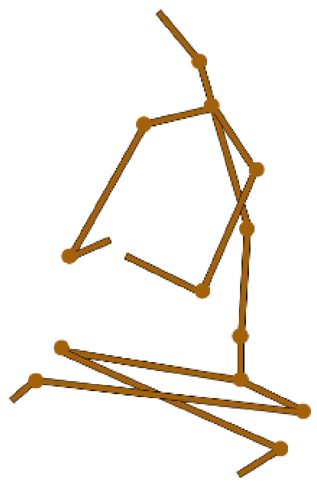

Figure 6. Stick diagram of the new working posture.

Table 5. Comparative postural stress of Matharkaam activity

Traditional		Prototype	
REBA* Score	**Action Level**	**REBA* Score**	**Action Level**
9	High Risk. Investigate and Implement Change	**6**	Medium Risk. Needs further investigation.

*Rapid Entire Body Assessment (REBA) (n = 33)

It is also necessary to note that, as a diminishing handicraft, using machines for Matharkaam cannot be implemented because they will subtract from the vessels' uniqueness and will require a higher financial investment. Furthermore, as previously said, their small workspaces do not allow for a workstation with a chair for the artisan.

5. Discussion

Tambat Ali Coppersmiths are a unique cluster of handicraft artisans. Their unique process of aestheticism of copper vessels called "Matharkaam" necessitates awkward postures for prolonged periods to complete which often leads to discomfort in their different body parts. According to Kivi and Mattila (1991), awkward working posture is mainly associated with the development of musculoskeletal disorders (MSD).

The aim of the study was to analyse the Tambat Ali Coppersmiths' current Matharkaam workstation and the postural discomforts that result from it in order to generate insights that would help us redesign the workstation to help alleviate discomforts while improving productivity.

We see that all major activities in the copper vessel-making process, such as moulding, acid-washing, Matharkaam, buffing, polishing, and storage, take place in their small workshops. The total surface area of the workshops is insufficient to accommodate all of the necessary activities in a secure and efficient manner. This necessitates the creation of small ergonomic interventions that can cater to both the performance and the protection of the operation.

Working posture and sensitivity to postural risks and discomforts were assessed using interviews and ergonomic evaluation techniques. The lower back, upper arm, shoulder blades, and wrists were found to be the most vulnerable to pain. As seen in **Figure 3**, this was triggered by the uncomfortable static stance and hunchback while performing Matharkaam. The Matharkaam artisans work nine to ten hours a day, six days a week in these postures. These work hours aren't enough for recuperation, thus affecting the artisans' physical health. This is consistent with Ganguly et. al (2015) where they reported that the majority of the problems of the metal industry were due to poor ergonomics, improper workstation design, nature of work, metal dust and inadequate rest of the workers.

The artisans' working posture when performing Matharkaam was assessed using REBA and QEC protocols. These results were consistent with the study done by Habibi et. al (2013) where the results obtained from the Nordic Questionnaire showed that 50% of workers in their study suffered from pain and discomfort in at least one of the upper limbs like shoulder, elbow, wrist, and fingers. The findings are also consistent with Ghosh et al. (2010) which reported that most of the goldsmith workers in their study were affected by occupational disorder wherein 80% reported pain in their neck, 20% reported pain in their shoulders, 45% reported pain in their wrists, and 75% reported pain in their lower backs.

The high scores for poor posture can be attributed to awkward working posture, strain and tension on the back, shoulders, arms and legs, static posture for long hours, and bent legs. These results also match the study done by Das et al. (2020) which reported that musculoskeletal symptoms in neck, back and knees among handicraft workers are highly associated with sustaining non-neutral working for a long duration of time during their work.

Another major risk factor amongst the artisans was the hammering with unsupported wrists. This means that the hammering on the copper vessel is done without any support on the underside of the wrists and thus, there is more pressure and sudden jerks on the wrist joint. Furthermore, while hammering, the wrist is twisted, side-bent and in extreme flexion. This puts muscular tension onto the neck, shoulder and arms. According to Bhattacharya and McGlothlin (2012) in Occupational Safety, awkward hand positions may result in the soreness of the wrist, loss of grip, and, if sustained over extended periods of time, the occurrence of carpal tunnel syndrome. It was further observed that the copper vessel-making process was done in natural light or in a dimly-lit workshop. The workshops were poorly illuminated to perform precision work. This increases the strain on the eyes of the artisans to efficiently and accurately perform Matharkaam. To address these problems, adequate lighting must be mounted, with fair spacing between lights to avoid casting shadows over the work-space.

Overall, the poor working conditions of the Tambat Ali copper-smith artisans have had a significant effect on their productivity and morale. The current state of the workshops is recognised to be as the standard since the same working conditions have been enforced since decades. According to Sohrabi (2018) practical checklist guidelines, simple and cost-effective interventions can be designed to improve the level of ergonomics and the health of the artisans. This would aid in productivity growth while also lowering workplace risks. Anti - vibration gloves could be worn to reduce the impact during the hammering process (Singh et al. 2020).

An ergonomically feasible solution was prototyped after gathering insights from the assessment of the exposure to occupational risks which will help improve the uncomfortable working posture, minimise body pressure, and increase productivity among artisans. **Figures 4 and 5** show the redesigned workstation.

The revamped workstation's working posture is depicted in **Figure 6**. The redesigned workstation will assist in maintaining the working body posture closer to a neutral posture. Because of the workstation's height, the artisan's back is no longer hunched or bent. As a result, their back, arms, and shoulders are less strained. By raising the copper vessel to the artisan's eye level, the elevation also helps to alleviate pressure on the neck and eyes. The workstation can be modified to fit the needs of the artisan. The wrists and lower arm are protected by the support provided by elevation of the workstation. Tension and strain in the shoulders and upper arm is expected to be relieved by providing this support. Thus, the wrists' vulnerability to repetitive workplace risks is reduced. Since the new workstation is foldable, it also helps to conserve space in the workshop.

The redesigned workstation is able to reduce the REBA score of the working posture from 9 (in the traditional workstation) to a 6. This proposed redesign would assist artisans in not only enhancing their posture but also increasing their efficiency and morale. This would be critical in gaining government support for increasing the wage rate per commodity as well as in publicising the product and handicraft.

6. Conclusion

There is a scarcity of literature available on the traditional Tambat Ali coppersmiths and their working postures. As a result, this research has provided a perspective on the artisans' postural stress and suggested a redesign of their workstation.

The updated workstation is a lightweight folding table that will help the artisans to store it without contributing to the clutter in their workshops. The new workstation will also help protect artisans from Cumulative Stress Disorders and Work-Related Musculoskeletal Disorders. It is a long-lasting, low-maintenance, and inexpensive update to their traditional workstation that can be produced by local vendors.

Future scope for the study includes focus on-

1) Evaluating the working postures of the different activities in the copper vessel-making process,
2) Improving the entire layout of the Tambat Ali workshops,
3) Sensitising the artisans to use better personal protective equipment, and redesigning the tools and equipment used to be more ergonomic to use and fit in their small workshops.

7. Limitations

The research was centred on the Matharkaam activity in a small section of the copper vessel-making community in Pune, India. Future research may involve coppersmiths from various regions as study participants. Because of their heavy workloads, only a few artisans decided to participate in the user report, which was limited to 33-35 artisans. As shown in **Figure 1**, this research only looks at one aspect of the entire copper-vessel manufacturing process, which is Matharkaam.

The revamped workstation relieves the artisan's upper body of stress and strain, but pressure is still applied to the gluteal area. To fix the lower body strain, further improvements to the revamped workstation are needed.

Furthermore, field usability testing is also required to determine the artisans' acceptance of the proposed workstation in comparison to their current workstation and to assess the new design's postural implications.

8. Acknowledgements

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References

Bhattacharya A and McGlothlin JD. 2011.Appendix B: Ergonomics Checklists In: Occupational Ergonomics: Theory and Applications. Second Edition. CRC Press. doi: https://doi.org/10.1201/b11717.

Das, D., Kumar, A., and Sharma, M., 2020. A Systematic Review of Work-related Musculoskeletal Disorders among Handicraft Workers. *International journal of occupational safety and ergonomics: JOSE* 26 (1): 55-70. doi: 10.1080/10803548.2018.1458487.

Corlett, E. N., and Bishop. R. P., 1976. A Technique for Assessing Postural Discomfort. *Ergonomics* 19 (2): 175-182. doi: 10.1080/00140137608931530.

David, G., Woods, V., Li, G., and Buckle, P., 2008. The Development of the Quick Exposure Check (QEC) for Assessing Exposure to Risk Factors for Work-related Musculoskeletal Disorders. *Applied Ergonomics* 39 (1): 57-69. doi: 10.1016/j.apergo.2007.03.002.

Ganguly, M., Patsa, M.K., Ghosh, A., and Ganguly, A., 2015. An Insight to the Bell Metal Industry of Bankura, West Bengal, India. *International Journal of Life Sciences* 5 (2): 105-111.

Ghosh, T., Das, B. and Gangopadhyay, S., 2010. Work-related Musculoskeletal Disorder: An Occupational Disorder of the Goldsmiths in India. *Indian Journal of Community Medicine* 35 (2): 321–325. doi: 10.4103/0970-0218.66890.

Habibi, E., Zare, M., Haghi, A., Habibi, P., and Hassanzadeh, A., 2013. Assessment of Physical Risk Factors among Arti sans Using Occupational Repetitive Actions and Nordic Questionnaire. *International Journal of Environmental Health Engineering* 1 (1): 1-6. doi: 10.4103/2277-9183.110158.

Hignett, S., and McAtamney, L., 2000. Rapid entire body assessment (REBA). *Applied Ergonomics* 31(2): 201-205. doi: 10.1016/s0003-6870(99)00039-3.

Kalkis, H., 2015. Economic Analytical Methods for Work-related MSD Cost Prediction. *Procedia Manufacturing* 3:4181-4188. doi: https://doi.org/10.1016/j.promfg.2015.07.393.

Kivi, P., and Mattila, M. 1991. Analysis and Improvement of Work Postures in the Building Industry: Application of the Computerised OWAS Method. *Applied Ergonomics* 22 (1): 43-48. doi: 10.1016/0003-6870(91)90009-7.

Kuhn, S., Milasi, S., and Yoon, S. 2018. World Employment Social Outlook: Trends 2018. *Geneva: ILO*.

Li, G., and Buckle, P.,1998. A practical method for the assessment of work-related musculoskeletal risks-Quick Exposure Check (QEC). In: *Proceedings of the human factors and ergonomics society annual meeting* (Vol. 42, No. 19, pp. 1351-1355). Sage CA: Los Angeles, CA: SAGE Publications.

Mediratta, A., (2019, September 11). Unorganised growth. Retrieved June 10, 2020, from: https://www.thehindubusiness-line.com/opinion/columns/unorganised-growth/article29385181.ece.

Singh, A. K., Meena, M. L., Chaudhary, H., and Karmakar, S., 2020. Assessment of transmissibility of hand-arm vibration, noise exposure, and shift in hearing threshold among handicraft operatives': a cross-sectional study. *Journal of Industrial and Production Engineering* 37: (2-3): 134-147. doi: https://doi.org/10.1080/21681015.2020.1737841.

Sohrabi, M. S., 2018. Simple and Low-Cost Ergonomics Interventions in Isfahan's Handicraft Workshops. In: *Proceeding of the 20th Congress of the International Ergonomics Association* (pp. 60-70). Springer, Cham. doi: https://doi.org/10.1007/978-3-319-96068-5_7.