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Postural Risk Analysis of Female Artisans Engaged in Traditional Bell Metal Castings Handicraft in India

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Abstract: Female artisan of the Bell metal handicraft industry spends prolonged time performing handcrafted precision and forceful tasks, which are known to cause occupational risks among the artisans. The objective of the study was to find out work-related risk factors affecting the health condition of female artisans. Qualitative and quantitative assessment was conducted with the help of questionnaire to identify the existing postural and body discomfort. The result showed that the young artisans faced the most discomfort in their upper limbs due to performing several bending and twisting activities for long hours. Ergonomics interventions in the form of improved hand tools and workstations will help female artisans to enhance their performance by avoiding awkward postures and reducing body-part discomfort.

Keywords: Occupational stress; Musculoskeletal Disorder; WRMSD; MSME; Women workforce

1. Introduction

Handicraft has a rich past in South Asian countries from time immemorial[1)]. Globally, India is the leading producer and supplier of handicraft products[2)]. According to the world bank data, 78% of the unorganized workers are in the handicraft sector and the role of the handicraft sector in world GDP is 27.49% [3)]. Rural India is the pillar of Handicraft production and 78% of total handicraft production of the country is accountable by rural artisans[3)]. The handicraft industry in India is the largest employers for the weaker section of the society[4) 5)]. This industry is highly labour intensive, cottage-based, and decentralized. One such traditional handicraft industry of India, is "Artmetal wares". Wax method of casting artmetal known as Dhokra craft have a history from Mohenjo-Daro and Indus Valley Civilization[6)], which plays a vital role in the country's economy even today[7)]. The Dhokra handicraft has the key potential for sustainable employment generation and exports revenue, retaining the cultural heritage of India. Dhokra is a non- ferrous metal casting process known as Lost wax casting or investment casting technique. The demand for this artifact is high, but the production rate is gradually decreasing due to the lack of workforce. Both male and female artisans are involved in the craftsmanship, but females are more prone towards getting musculoskeletal disorders (MSD) as they perform both household activity as well as spend long hours for commercial production in makeshift workstation involving awkward posture[8)].

In India, from ages due to household responsibilities women were mostly involved in home-based production for earning[5)]. Under MSME (Micro, Small & Medium Enterprises) handicraft is one of the home-based production sector and as per world bank data, 87% of women are engaged in handicraft for their livelihood[2)]. Lack of education and early marriage due to social customs but highly skilled hand craftsmanship which is inherited, the handicraft sector is ruled by women workforce[3)]. Female artisans in Dhokra handicraft industry in Chhattisgarh are highly skilled and found to be higher in number in comparison to male artisans[9)]. They are from tribal communities and practicing this craft from generation[10)]. In recent times, it is observed that Dhokra male artisans are leaving their traditional craft profession in search of jobs in different cities and women of the households are carrying forward their traditional age old practice to commercial industry with the flow of time. Maintaining both the jobs with household responsibilities and heavy manual labour at workplace, women workforce is overly burdened in comparison to men workforce and are exposed to different occupational health issues[11) 12)]. In the handicraft sector, working hours, work posture, repetitive tasks and stressful work environment are the major risk factor for developing work-related musculoskeletal disorders (WRMSD)[13)]. Due to commercialization, working hours have increased, but the workplace and work processes remain the same, affecting the occupational health of the female artisans, affecting

their workability and ultimately, they suffer from economic loss[14) 15)].

Female workers in the golden thread work industry spend long working hours without taking small breaks between the work, affecting their other household activities[15)]. The study on hand block textile printing performed pre and post analysis, where many artisans complained about WRMSD due to heavy work load[14)]. Workers with musculoskeletal issues experienced little to extreme pain in their skeletal muscles[16)]. If static force is applied to the muscle repeatedly and continuously for a prolonged time, the muscle may experience symptoms in the form of joint, ligament and tendon injury[16)]. Musculoskeletal problems is triggered by excessively demanding workload with a prolonged muscle contraction, this results in low blood flow to muscles compared to the strength of contraction, resulting in less oxygen supply to the muscles, causing the buildup of lactic acid and muscle soreness[17)]. A study on female workers involved in 'jari' work found different ground sitting postures adopted by the workers for long-duration precision work, which were found to be stressful and led to the development of MSD[18)]. To protect workers from occupational stress, ergonomic workplace and optimized manufacturing process must be considered to utilize long working hours[16)]. In the present study female artisans work in the same traditional workplace for commercial production, where they follow a traditional manual manufacturing process which results in a delayed commercial production process, reducing the productivity of the female artisans and ultimately losing their workability[8)]. These factors affect the female artisan's motivation, increase absenteeism, and they lose interest to continue with full potential[19) 20)].

Women artisans play a significant role in the handicraft industry, where they help to pass creative experiences to the young generation and parallelly balance household activities. But currently, after the commercialization they still have pressure to fulfil their commercial demand, while they have different occupational health issues and struggle hard for their livelihood. This study aims to assess the postural risks and body-parts discomforts of the female artisans engaged in Bell metal handicrafts. The objective of the study was to find out work-related risk factors affecting the health condition of female artisans.

2. Materials and Methods

2.1 Subject Selection

The study was conducted in the Kondagaon district of Chhattisgarh, India. A total of 127 female artisans were selected from 83 workshops, out of which 109 were convinced and consented to conduct the interview and questionnaire study. This study was carried out between January to March of 2023. Demographic data were taken. BMI value [21)] was calculated using the weight and height data of the female artisans.

2.2 Posture Study

The methods applied for the assessment of postures are RULA (Rapid Upper Limb Assessment)[22)], REBA (Rapid Entire Body Assessment)[23)] and OWAS (Ovako Working Posture Analysis System)[24)] for different steps of the crafting process (Figure 1) at the workplace.

2.3 Body Discomfort Analysis

Modified questionnaires of Standard Nordic questionnaires[25)] consisting the set of questions regarding discomfort in a particular part of the body and to measure and check MSD symptoms. The Numeric rating Scale[21)] consisted of scores 1 to 5, where 1 was designated as 'comfortable' and 5 as 'extremely uncomfortable'.

2.4 Statistical Analysis

To analyze data collected feedback data from interviews and modified Nordic questionnaire basic statistics like mean, percentage and standard deviation were used. The chi-square test was used to find the categorical difference between the independent variable (age and experience) and the dependent variable (discomfort in different body parts).

3. Result

The mean value of the age of the female artisans was 34.025(±11.8), with 17 years being the minimum age and 60 being the maximum age. Female artisans' mean height was 151.01(±8.5) and weight was calculated as 44.7(±4.15) in order to find the mean BMI value, which was calculated as 19.7(±2.7) as shown in Table 1.

Table 1. Demographic data of the female artisans (n=109)

Parameter	Min	Max	Mean (Standard Deviation)
Age (Years)	17	60	34.025 (±11.8)
Height (cms)	131	164.6	151.01 (±8.5)
Weight (kgs)	35	50	44.7 (±4.1)
BMI Value (kg/m²)	17.2	26.2	19.70 (±2.7)
Work experience (yr)	5	35	13.0 (±8.17)
Daily working hours (hr)	8	10	9.11 (±0.80)
Work day per week	6	7	6.44 (±0.49)

Female artisans took care of their homes and were involved in Dhokra craft manufacturing. The average working hours of these female artisans were 9.11(±0.80) hrs per day and 6 days per week. All the artisans selected in this study have a minimum of 5 years and maximum 35 years of work experience and having an average experience of 13(±8.17) years.

The postural analysis of the different activities performed during the crafting process was measured with the help of RULA, REBA and OWAS. All the activities

were divided into eight different steps as mentioned in Figure 1 which involved attaining more than one posture.

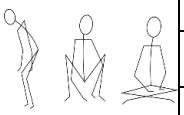
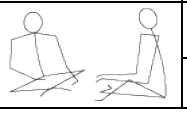
Fig. 1: Dhokra crafting process consisting of different steps

In the First step, the mould was prepared by mixing rice husk and soil, which was done by both hands and legs. Then wax threads are prepared using a traditional handmade device. It was noticed that the present workstation does not follow ergonomic design criteria and thus the artisans tend to perform work in an awkward position. The next step involves making the ornaments for the final artefacts with the wax threads, which involves hands with traditional tools.

The designs using wax threads are made with precision which requires skills to make intricate designs. In the next step, brass is melted for pouring purposes in one furnace and in another furnace, the moulds are kept for drying. Due to extreme environmental heat, female artisans are usually not involved in metal casting-related activity in furnaces. Once the moulds get cooled out from the furnace, the outer mud layer is removed by hammering. Later the artefacts are cleaned and buffed with the buffing machine.

RULA, REBA and OWAS methods were adopted to analyze the different postures of the female artisans and determine the body parts affected due to the nature of the work. As shown in Table 2, postures attained in steps 2, 3, 5 and 6 suggest urgent changes and solutions as they are at high risk of getting Musculoskeletal disorders as per the symptoms observed and analyzed.

Table 2. Analysis of Postures mean score during craftsmanship of female artisans (n=109)

Dhokra Crafting Activities	Posture of Artisans			Posture Analysis Tool				
	A	B	C	OWAS	RULA Score		REBA Score	
					Right	Left	Right	Left
1. Mould Making				3.45	3.37	2.62	9.53	9.14
				3.55	6.49	6.33	7.51	7.17
				2.47	6.45	6.21	6.48	6.05
2. Wax Making				2.63	6.60	5.46	11.52	11.15
				2.48	3.45	3.21	9.52	9.14
				2.55	6.44	6.17	11.44	10.87
3. Wax Design Making				2.57	6.48	6.14	10.44	10.1
				2.56	5.53	5.33	5.55	5.12
				2.54	5.35	5.14	5.44	4.91
4. Ornament Design				2.49	4.54	4.66	7.58	6.78
				1.50	5.53	5.22	10.44	9.63
				2.55	6.55	6.20	6.55	5.99
5. Clay Layering				3.56	6.50	6.33	11.47	10.98
				2.57	4.45	4.07	6.44	5.80
6. Furnace				3.61	6.55	6.37	11.42	10.41
				1.50	6.44	6.23	9.54	8.98
				2.51	6.45	6.14	10.48	9.80
7.Remove mould				3.50	6.41	6.13	7.44	6.77
				1.58	3.44	3.18	6.44	5.87
8. Buffing				2.43	6.48	6.26	7.44	6.83
				2.46	4.53	4.17	6.52	6.24

The Nordic score calculated using the Nordic questionnaire is shown in Figure 2. In the upper limb area, the discomfort was majorly seen in the wrist/hand (65.5%), elbow (60.5%) and shoulder (54.5%) where as in the lower limb area, Knee (67%), lower back (58.5%) and hip/thigh (44.5%) are the parts where discomfort was observed.

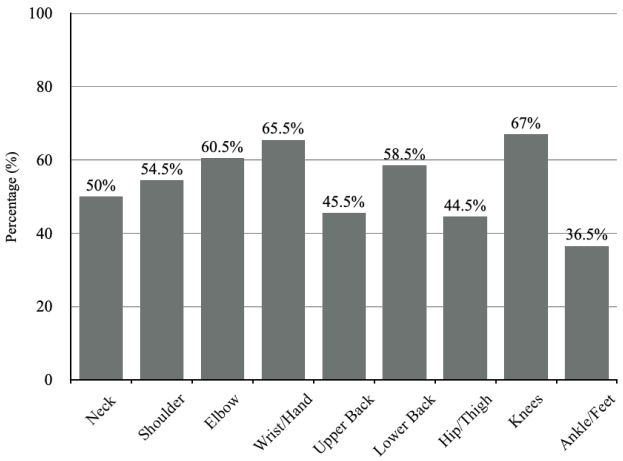


Fig.2: Nordic Score for frequency of discomfort

The prevalence of different body discomfort with respect to demographic characteristics (age and experience) (Table 3) was evaluated using the chi-squire test (Table 4), where the number of female artisans and their percentage with the demographic group were considered for the study and p-value less then 0.05 was considered statically significant.

Table 3: Demographic characteristics of female artisans (n=109)

Variable	Classification	n (%)
Age, years	(20-30)	28 (25.69)
	(31-40)	27 (24.77)
	(41-50)	28 (25.69)
	(>50)	26 (23.85)
Experience, years	(0-7)	28 (25.69)
	(8-14)	26 (23.85)
	(15-21)	26 (23.85)
	(>21)	29 (26.61)

It was found that (Table 4) the level of discomfort in the upper limb such as neck (64.2%) and wrist (64.2%) was high for the age group <20-30 years with 0-7 years of experience. The discomfort in shoulder (88.4%) and knee (82.1%) were high among artisans with the age group >50 years and >21 years respectively. While no significant difference was found in elbow, upper back, lower back, thigh and ankle, which reveals that the prevalence of discomfort is common among artisans in all age and experience groups.

Table 4: Demographic characteristics of the female artisans with respect to prevalence of body discomfort (n = 109)

Demographic Characteristic (n = 109)		Discomfort in different body part					
		Neck		**Shoulder**		**Elbows**	
Variable	Classification	n (%)	P-value	n (%)	P-value	n (%)	P-value
Age (Years)	(20-30)	18 (64.2)	<0.05*	6 (21.4)	<0.01 **	20 (71.4)	<0.05*
	(31 to 40)	13 (48.1)		11 (40.7)		13 (48.1)	
	(41 to 50)	6 (21.4)		17 (60.7)		6 (21.4)	
	(>50)	3 (11.5)		23 (88.4)		5 (19.2)	
Experience (Years)	(0-7)	18 (64.2)	<0.05*	5 (17.8)	<0.05*	21(75.0)	-
	(8-14)	15 (57.6)		11 (42.3)		12 (46.1)	
	(15-21)	6 (23.0)		15 (57.6)		6 (23.0)	
	(>21)	4 (13.7)		24 (82.7)		8 (27.5)	
Demographic Characteristic (N = 109)		**Wrist/Hand**		**Upper Back**		**Lower Back**	
Variable	Classification	n (%)	P-value	n (%)	P-value	n (%)	P-value
Age (Years)	(20-30)	18 (64.2)	<0.05*	13 (46.4)	-	10 (35.7)	<0.05*
	(31 to 40)	6 (22.2)		19 (70.3)		19 (70.3)	
	(41 to 50)	3 (10.7)		20 (71.4)		8 (28.5)	
	(>50)	3 (11.5)		21 (80.7)		23 (88.4)	
Experience (Years)	(0-7)	18 (64.2)	<0.05*	13 (46.4)	-	10 (35.7)	-
	(8-14)	6 (23.0)		18 (69.2)		17 (65.3)	
	(15-21)	3 (11.5)		20 (76.9)		9 (34.6)	
	(>21)	2 (6.8)		21 (72.4)		24 (82.7)	
Demographic Characteristic (N = 109)		**Hip/Thigh**		**Knees**		**Ankle/Feet**	
Variable	Classification	n (%)	P-value	n (%)	P-value	n (%)	P-value
Age (Years)	(20-30)	3 (10.7)	<0.05*	8 (28.5)	<0.01 **	11 (39.2)	-
	(31 to 40)	14 (51.8)		3 (11.1)		3 (11.1)	
	(41 to 50)	20 (71.4)		23 (82.1)		9 (32.1)	
	(>50)	6 (23.0)		12 (46.1)		9 (34.6)	

Experience (Years)	(0-7)	3 (10.7)	-	8 (28.5)	<0.05*	10 (35.7)	-
	(8-14)	12 (46.1)		3 (11.5)		3 (11.5)	
	(15-21)	18 (69.2)		18 (69.2)		9 (34.6)	
	(>21)	11 (37.9)		16 (55.1)		8 (27.5)	
n= Number of artisans, %=Percentage value, * = p<0.05, ** = p<0.01, ***= p<0.001							

4. Discussion

The handicraft sector is considered a job requiring a lot of physical work[26]. The female artisans continued to work in the same awkward positions for a very long time, which exposed them to different body discomfort. This study of posture analysis inferred that the female artisans have developed MSD and the intense scenario requires immediate action and needs ergonomic intervention to ensure the health and safety of female artisans and improve their productivity which is also found in other studies[27-29]. The Nordic score also revealed discomfort in the upper limb, especially in the wrist/hand and elbow, which involve precision designing tasks and machine handling. In the brass metal handicraft industry, they had the same discomfort in their upper limb area[30] [8]. A similar study in the unorganized sector also revealed that precession-based activities such as hand block printing, bell metal craft, pottery, sculpture, etc., have the most discomfort in the upper body part[31-35] and in the lower limb, due to sitting in inappropriate and uncomfortable positions, pain is observed in the lower back, knee, and thigh which is the resulting factor of MSD[36]. A similar study also showed that the monotonous and tedious precision work done by the female artisans in the same sitting posture leads to increased problems of neck, arms and shoulders[37]. The squatting position where female artisans work continuously develops stress on the knees because the pressure is applied on the knee joints, possibly leading to knee injury[38]. In the long term, occupational discomfort exposed the artisans for risk of occupational injuries[39] [40]. These will increase their emotional distress and ultimately loss the workability[41] [42]. Ergonomics intervention in workstation and workplace layout help to reduce occupational stress by improving awkward work posture in footwear production industry[43]. Similarly, modified workstation design helped to reduce musculoskeletal disorders where dairy farm workers were involved in frequent load-lifting activities[44]. In the existing condition ergonomics intervention in the assembly line will help to increase the artisan's productivity by improving their working posture through workstation redesign. The limitation of the study is that detailed task analysis of the work process and anthropometric dimensions of the artisans with the existing workstation was not considered. These factors will be considered for the future study for the effective design and development of ergonomic designed workstation to reduce postural load among women artisans.

5. Conclusion

This paper concludes that due to the commercialization of Dhokra Bell metal handicraft sectors, the female artisans worked in inappropriate and awkward postures in the workplace for considerable long working hours. Women artisans have two jobs; as homemakers doing all household work and artisans in the commercial sector, responsible for timely quality production. Switching between work and household activities causes reduced resting time for muscle recovery among women artisans resulting in the development of work related musculoskeletal disorder WRMSD. Steps towards ergonomic intervention in workstation design can improve the workability of female artisans and boost their confidence and improve their skills for better productivity.

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Disclosure

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