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A Comparative Ergonomics Postural Assessment of Potters and Sculptors in the Unorganized Sector in West Bengal, India

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Potters and sculptors perform their work in very awkward postures. The purpose of this study was to analyse these postures. The modified Nordic questionnaire was used to analyse musculoskeletal discomfort. Rapid entire body assessment (REBA) and rapid upper limb assessment (RULA) were used to evaluate the subjects' postures. There were no significant differences between times of discomfort and the group of subjects. However, there were significant differences in discomfort in different body parts. The analysis indicated that various body postures were harmful to the subjects and that there were profound deviations from natural curvature of various body parts due to awkward body postures. Ergonomics intervention was required to improve the quality of life.

ergonomics posture musculoskeletal disorders low back pain REBA RULA

1. INTRODUCTION

Pottery and clay sculptures from India have always been admired for their unique beauty and ethnic value. They are produced mainly in the villages in West Bengal, India [1, 2], but are exported to various countries throughout the world. This kind of art requires extreme physical effort, tenacity and skill from the makers. Most makers are men who devote their entire life to this art; the tradition continues from generation to generation. Pottery and sculptures require tremendous skills. Repetitive body movements of the makers have been observed, but there are not enough data on health problems, postural stress and other ergonomics aspects of workers in India. Although that pottery and sculptures are admired around the world, there are no studies on the working environments of the workers. Sitting postures while making pottery and sculptures are very awkward. Body postures depend on various circumstances, e.g., the type of work and the workplace, individual characteristics,

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specific tools and on the frequency and the duration of the work cycle [3, 4]. Potters' and sculptors' jobs are associated with musculoskeletal disorders (MSDs) of various body parts [5, 6]. Deteriorating working conditions cause physiological problems, which have a negative impact on the workers.

According to the National Institute for Occupational Safety and Health, lower back pain is caused by an inappropriate workstation [7]. Moreover, discomfort increases with the age as aged people refuse to modernize their workstation [8, 9]; this is also important for physiological disorders among workers [9]. The prevalence of MSDs in the developing countries is obvious because of the lack of knowledge of proper material handling and physiologically proper postures [10, 11, 12, 13]. Many physiological disorders, in addition to MSDs, have been reported so far, e.g., malnutrition, and respiratory and cardiovascular disorders [14]. As not much attention is paid to the potters and sculptors in West Bengal [1], their working status and environment does not change. The aim of this study was to evaluate postural stress and prevalence of MSDs among potters and clay sculptors.

2. METHODS

2.1. Location

Nadia district is famous for pottery and earthen sculptures, which are exported to various countries. The study took place in four locations near Krishnagar, the capital of the district [1, 2]. The inhabitants of two locations produce pottery and the inhabitants of the other two produce earthen sculptures. All areas are situated ~100 km from Kolkata, the capital of West Bengal, India.

2.2. Subjects

The group of potters consisted of 80 randomly selected male potters (mean age 46.58 ± 10.46 years). The group of sculptors consisted of 50 randomly selected clay sculptors (mean age 43.56 ± 8.51 years). All of them had minimum 5-year work experience. The subjects were informed about the protocol of the study before they gave their written consent.

2.3. Physical Parameters

The potters' and the sculptors' height and weight were measured with a Martin anthropometer (Takei, Japan) and a digital weighing machine (Omran, India), respectively. The body surface area (BSA) [15] and the body mass index (BMI) [16] of all subjects were also computed.

2.4. Daily Work Schedule

The working schedules of the potters and the sculptors were observed carefully. The tasks of both groups are the same; however, their modes of work are different. Bringing soil from a store to the workplace is the main task. Later, the subjects prepare it with water, place it in a cast or on a wheel, create the product, and dry it in the sun or bake it in an oven. Finally, they paint it.

The subjects from both groups begin their regular work early in the morning. The modes of work of both groups are the same until the preparation of soil. The potters prepare soil with water. They crush it with feet and then with hands. This job is strenuous; it generally takes 2–2.5 h. However, the exact duration of this type of work varies according to the type of soil and the preparation time with hands and feet. Generally, the potters use an electrical or a hand-driven wheel. The potters put wet soil in the centre of the wheel, rotate it and make various items with different movements and force only. While working, they sit on the ground, raise both knees and bend the spine like a bow with the neck between their knees. The potters work for 12–13 h a day and sit for 5–6 h at a stretch. The time necessary to produce an item depends on its type. Making a cup or a glass takes less time than making a flower tub. The production depends on the type of clay. Although the productivity and time depend on the product, the total time for each step is different for each potter. Drying the product in the sun is also laborious and generally takes 1–1.5 h. This job requires special attention because any minute disturbance can spoil the product.

Clay sculptors use different production methods. Instead of wheels, they use casts made of plaster of Paris. They put wet soil into the casts; then, they remove a formed product and smooth it with a flat knife made of a bamboo. The potters' and the sculptors' schedules are similar. However, their sitting postures and modes of work are different. The sculptors' productivity and cycle time are not the same as the potters'. The production of a single model or a doll takes more time than the production of a glass, a cup or a tub. The sculptors' sitting time and body movements do not differ from those of the potters'. The models dry in the sun; they are not baked. The drying time for pottery and sculptures is the same. The sculptors paint dry products. The sculptors' posture supports their backs with the wall and allows them to spread legs. When the sculptors colour their products, they bend to see the product better and to be more precise. The exact durations of the modes of work are not known. Colouring models takes over 12 h a day. Normally, the sculptor spends 6–7 h at a stretch on colouring products.

2.5. Working Postures

Various methods are used to assess work-related stress [17]. Postural stress of the upper extremities was analysed with rapid upper limb assessment (RULA) [18] like in other studies [19, 20, 21]. RULA included three steps. First, the postures were selected. Then, they were scored with a scoring sheet. At the end, the results were put together in tables and converted to scores (1–7), which were grouped into four action categories (ACs) [18, 19, 20, 21].

Working postures of the potters and the sculptors were analysed with rapid entire body assessment (REBA) [22]; digital photography was used. This technique was also used to assess postural stress. The body parts were grouped into two categories. Group A included the trunk, neck and legs; and group B included upper arms, lower arms and wrists. Each body part was evaluated depending on the load/force, coupling factors and activities. The scores were calculated to get the final score, which was then assessed according to the proposed ACs [22]. Stick diagrams were drawn from the freeze-frame and analysed. The most frequent postural conditions were considered.

2.6. Questionnaire Study

A study based on the modified Nordic musculoskeletal questionnaire evaluated postural stress of the potters and the sculptors [13, 23]. The questionnaire consisted of a series of questions with multiple-choice responses grouped into two parts: (a) working conditions and (b) physiological health. The questionnaire helped to assess the working environment and duration of work, and to evaluate physical work load and physiological health. Discomfort/pain in different body parts and onset of discomfort/pain were recorded; the results simplified assessing discomfort/pain at different times. The questionnaire also included questions on the time of feeling maximum discomfort/pain (i.e., morning, afternoon, evening or night) and affected body parts (neck, shoulder, lower back, wrist, hand or leg).

2.7. Discomfort Scale

Degree of discomfort/pain of the potters and the sculptors was assessed on a 1–10 body parts discomfort scale [24], where 1 = *first feeling of discomfort/pain or identifiable discomfort/pain*, 5 = *moderate discomfort/pain*, 10 = *maximum or intolerable discomfort/pain*. The subjects graded their discomfort/pain.

2.8. Statistical Analysis

Means and standard deviation were calculated. The χ^2 test compared mean discomfort in the different body parts ($p < .05$) [25]. The second χ^2 test analysed significant changes in discomfort in various body parts and the various discomfort phases. Yates's corrections were done for standard χ^2 values. A hypothesis test for proportions was performed to analyse the tendency of deviation of the outcome [25].

3. RESULTS

Table 1 shows mean values of age and the physical parameters (height, weight, BSA and BMI) of

TABLE 1. Characteristics of Potters (n = 80) and Sculptors (n = 50)

	Potters		Sculptors		
Parameter	***M***	***SD***	***M***	***SD***	***t***
Age (years)	46.58	10.46	43.56	8.51	1.360
Height (cm)	165.47	6.26	164.90	6.42	0.380
Weight (kg)	58.43	8.71	58.37	0.08	0.040
BSA (m^2)	1.70	0.14	1.69	0.08	0.080
BMI (kg/m^2)	21.32	2.79	21.32	1.47	0.001

Notes. There are no statistical differences ($p < .05$); BSA = body surface area, BMI = body mass index.

TABLE 2. Discomfort/Pain at Different Times Among Potters (n = 80) and Sculptors (n = 50)

Time	Potters (%)	Sculptors (%)	χ^2
At work	68 (85.00)	42 (84)	0.024
After work	19 (23.75)	13 (26)	0.006
Before or after sleep at night	12 (15.00)	17 (34)	5.360*
During 24 h after work	9 (11.25)	6 (12)	0.017

Notes. *Two-tailed significance value $p < .05$.

the potters and the sculptors, and standard deviation. Table 1 also presents the t value of each variable.

TABLE 3. Discomfort/Pain Among Potters (n = 80) and Sculptors (n = 50) in Different Body Parts

Body Part	Potters (%)	Sculptors (%)
Neck	69 (86.25)	43 (86)
Shoulder	20 (25.00)	8 (16)
Wrist	14 (17.50)	5 (10)
Hands	11 (13.75)	3 (6)
Lower back	71 (88.75)	44 (88)
Knee	12 (15.00)	17 (34)
Neck and shoulder	17 (21.25)	6 (12)
Neck and wrist	11 (13.75)	5 (10)
Neck and hands	5 (6.25)	1 (2)
Neck and lower back	46 (57.50)	42 (84)
Neck and knee	9 (11.25)	13 (26)
Shoulder and wrist	3 (3.75)	1 (2)
Shoulder and hands	7 (8.75)	2 (4)
Shoulder and lower back	6 (7.50)	6 (12)
Shoulder and knee	10 (12.50)	5 (10)
Wrists and hands	11 (13.75)	3 (6)
Wrists and lower back	14 (17.50)	5 (10)
Wrists and knee	6 (7.50)	5 (10)
Hands and lower back	11 (13.75)	3 (6)
Hands and knee	4 (5.00)	3 (6)
Lower back and knee	12 (15.00)	17 (34)

Notes. The values do not add up to 100 due to possible multiple responses.

The potters and the sculptors reported discomfort/pain in various body parts. Table 2 presents discomfort/pain at different times. The statistical significance of discomfort/pain in body parts at different times was analysed (χ^2 test).

Table 3 presents discomfort/pain in different body parts of the sculptors and the potters.

The statistical analysis (χ^2 test) evaluated the number of potters and sculptors suffering from a similar type of discomfort (Table 4). The potters and the sculptors suffered from neck and low back pain. Because most of the time they had to work with their backs bent, there was a high probability of MSDs in that body part.

Tables 5–6 show various postural conditions and their RULA and REBA scores for the potters and the sculptors, respectively.

4. DISCUSSION

All potters and sculptors had 5 years of work experience. They adopt awkward postures in their work. The subjects' poor financial conditions force them to work beyond their abilities [14]. The workstations are not ergonomically adjusted. The subjects do not have knowledge about the human body, so they are not aware of possible hazards. Except for soil preparation, they sit while working.

TABLE 4. Discomfort and No Discomfort Among Potters (*n* = 80) and Sculptors (*n* = 50) in Different Body Parts

	Potters		Sculptors		
Body Part	**Discomfort**	**No Discomfort**	**Discomfort**	**No Discomfort**	χ^2
Neck	69	11	43	7	0.002
Shoulders	20	60	8	42	0.990
Wrist	14	66	5	45	0.851
Hands	11	69	3	47	1.201
Lower back	71	9	44	6	0.017
Knee	12	68	17	33	5.360*
Neck and shoulder	17	63	6	44	1.228
Neck and wrist	11	69	5	45	0.129
Neck and hands	5	75	1	49	0.482
Neck and lower back	46	34	42	8	8.706*
Neck and knee	9	71	13	37	3.770*
Shoulder and wrist	3	77	1	49	0.002
Shoulder and hands	7	73	2	48	0.466
Shoulder and lower back	6	74	6	44	0.304
Shoulder and knee	10	70	5	45	0.023
Wrists and hands	11	69	3	47	1.201
Wrists and lower back	14	66	5	45	0.851
Wrists and knee	6	74	5	45	0.030
Hands and lower back	11	69	3	47	1.201
Hands and knee	4	76	3	47	0.060
Lower back and knee	12	68	17	33	5.360*

Notes. *Two-tailed significance value $p < .05$.

TABLE 5. Analysis of Potters' Working Postures

Posture	Activity	RULA Score	RULA AC	REBA Score	REBA AC	Body Part	Max Discomfort Rating[1]
	preparing soil with feet	4	2	7	2	legs	5.89 ± 1.17
	preparing soil with hands	6	3	7	2	lower back	6.66 ± 1.22
	preparing pot	5	3	6	2	lower back	7.5 ± 0.922
	placing product	6	3	6	2	lower back	6.47 ± 0.94
	drying in the sun	6	3	8	3	lower back	8.02 ± 0.91

Notes. RULA = rapid upper limb assessment, AC = action category, REBA = rapid entire body assessment; 1 = *M* ± *SD*.

TABLE 6. Analysis of Sculptors' Working Postures

Posture	Activity	RULA Score	RULA AC	REBA Score	REBA AC	Body Part	Max Discomfort Rating[1]
	preparing soil with feet	4	2	7	2	legs	5.37 ± 1.08
	preparing soil with hands	5	3	5	2	lower back	6.52 ± 0.94
	preparing model	4	2	4	2	neck	5.54 ± 1.07
	drying in the sun	6	3	8	3	lower back	6.33 ± 1.05
	colouring model	5	3	6	2	lower back	7.10 ± 1.15

Notes. RULA = rapid upper limb assessment, AC = action category, REBA = rapid entire body assessment; 1 = $M \pm SD$.

There were no significant differences between the potters and the sculptors in their age, height, weight, BMI and BSA (Table 1). Physiological conditions, i.e., weight and BMI were average, the subjects were not obese, overweight or underweight; their BMI was average [16]. The health status of the potters and the sculptors was average and did not have any dissimilarities. The subjects did not eat junk or fast food and they were not addicted to alcohol. Physical work helped to avoid excess body fat. Because BMI and BSA were directly proportional to weight, there were no differences in the parameters between the groups of subjects.

Table 2 shows that the times of discomfort/pain among the potters and the sculptors are not significant in relation to their working status. There is a significant difference ($p < .05$) between the groups of subjects in feeling pain before or after sleep at night. The proportionate test shows that the number of sculptors who feel pain before or after sleep at night is significantly higher ($p < .05$) than the number of potters. The reason for the difference between the groups of subjects in feeling pain at this specific time is not known. However, it is clear that both groups of subjects feel pain while they work. There are no significant differences in feeling pain at other times. The exhaustion after work causes muscles cramps in various body parts. The subjects work in a hot and humid environment, so they lose an excessive amount of body fluids; the lack of minerals and nutrient causes cramps and pain.

Table 3–4 show discomfort/pain in different body parts among the potters and the sculptors. The sculptors complain of pain in their knees, whereas the potters complain of pain in their shoulders, wrists and hands. Both groups of subjects suffer from neck and lower back pain. The proportionate test ($p < .05$) shows that the cumulative discomfort in body parts (i.e., neck and shoulder) is significantly higher for the sculptors in individual regions (i.e., neck and lower back, neck and knee, and lower back and knee). If the subjects continue to work in awkward postures, they will suffer from severe damage in the upper extremities [5]. Pain in the sculptors' neck and shoulder is profound because their backs are static for a prolonged time. Pain among the potters is relatively low because of some movements of their lower back. When the sculptors sit on the ground, their knees are bent and an extra load is applied to their joints, whereas the potters usually sit on a stool with their legs bent or stretched.

Stretched legs are supported and no additional force is applied to their joints and muscles.

Tables 5–6 present an analysis of working posture of the potters and the sculptors, respectively. REBA and RULA scores were calculated according to the subjects' postures at work.

REBA and RULA indicate which postures adopted for a specific type of work are hazardous and what actions should be implemented to protect the body. REBA score 7 for soil preparation with legs and hands (AC 2) indicates that these postures should be changed to avoid pain in legs and wrists. RULA score 4 for soil preparation with legs (AC 2) indicates a risk of limb deformity; improving working conditions is necessary. According to RULA, score 6 (AC 3) for soil preparation with hands is also alarming. This posture is not physiologically fit for workers.

The potters' activities like preparation and placing products also have high REBA and RULA scores (scores 6 and 5, respectively). These results are alarming; safety measure should be implemented to minimize damage to the lumbar spine. The sculptors' postures during model preparation cause less damage (both REBA and RULA scores 4, AC 2); however, they also need to be improved.

Drying the product in the sun is the most damaging posture the potters and the sculptors adopt. The high REBA (score 8, AC 3) and RULA scores (score 6, AC 3) indicate that this posture should be improved immediately to prevent severe damage to lower parts of the spine. The sculptors' posture adopted for model colouring affects the lower back. This posture can also be hazardous for eyes because products requiring precision are performed under poor illumination.

The aim of this study was to assess whether the postures adopted at work could be stressful for the workers. The subjects complained about pain in different body parts. This study revealed that necks and waists bent for prolonged time cause pain. The study established the relation between pain and postures. The results of the study proved that awkward postures cause pain. If the subjects work in awkward postures for a prolonged time, their limbs will be damaged. Changes in working conditions should be implemented immediately to protect the workers. Proper equipment, e.g., a seat and illumination, training with stretching exercises, will improve their quality of life.

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