LIST OF PUBLICATIONS
Full length research articles:


Conference proceedings:


214
1. INTRODUCTION

Brick manufacturing in India is a traditional, age old unorganised industry. Off late, due to rapid urbanisation and spurt in real estate development, this has become one of the flourishing industries. Although some mechanization was introduced in developed countries, but here the entire job is handled manually by highly primitive and traditional tools and methods. According to the NCEUS (2007), out of the total estimated workforce of 457.5 million workers, 148 million were women (roughly 38 percent). Out of which 142 million or nearly 96 of the total workforce are part of the unorganized sector [1].

The process of brick making involves several steps of which carrying is an essential part of brick manufacturing process, where a group of female workers designated as ‘carriers’, carry raw (sun baked and air dried) bricks from the stacks in the field to the brick kiln and baked red bricks back from the kiln, to stack in some other places in the field for export. Carrying is basically a repetitive and continuous work performed in awkward posture in which a high load of around 40 kg is handled by hand and head mode at a very high and humid environmental condition. Thus, the women workers have to work in more challenging and adverse working conditions which have made this a suitable base for conducting the study. Well-built and strong individuals have a greater capability to perform manual material handling (MMH) tasks than individuals who have a slight-build and are relatively weak. The later faces a great deal of difficulty in repetitive load handling and can get exhausted quickly particularly when the load is to be picked up from the floor [2]. Heavier individuals are generally stronger and have enough mass to handle higher capacity of load for infrequently performed MMH tasks [3].

Inadequate nutrition is one of the main factors contributed to poor health condition and also to the work performance. Proper nutrition helps an individual to maintain a good health, better physical fitness standard, and fit to perform any kind of jobs. Anthropometric measurements are important tools to assess the nutritional and health status of people depending on their respective energy intakes. Thus, it is essential to have a balanced diet to ensure adequate amount of necessary food stuffs, unless the work capacity will be diminished and the individual will become weaker as the body mass will gradually lose. Nutritionists have developed the concept of recommended daily allowance (RDA) of carbohydrate, protein, fat, vitamins and trace elements for different types of jobs. For an individual to be healthy and in good physical status throughout the life, his/her energy input must be equal to the energy output i.e., an equilibrium should be maintained between energy consumption and energy expenditure. In a study by Fami et al. [4] it has been observed that the total average energy intake is 2602 kcal/day for the rural women participated in mixed farming activities in Iran. But according to the FAO/WHO/UNU recommendations, a farm woman with an average body weight of 60 kg required 2,820 kcal/day [5]. Thus, it was seen that the subjects consumed about 200 kcal less than the FAO/WHO/UNU recommendations. Another study with women farmer by Singh et al., [6] showed that the mean energy intake is 2085 kcal/day and have a negative balance of 378 kcal/day. Similar negative balance was also reported with female agricultural workers [7]. Heart rate is one of the most accurate means of studying the physiological workload while performing any activity [8]. Varghese et al. [9] classified the workload in different household occupations based on heart rate and energy expenditure on women workers.

The present study was conducted to study the nutritional status of women working in brickfield, their daily time allocation, heart rate pattern, energy consumption, energy expenditure throughout the day while performing several activities and the relationship between their nutritional status and their participation in brick carrying activity.

2. METHODS

The study was conducted on 62 brick carriers working around several brickfields around Kolkata, with mean age of 25.8±3.24 years and having minimum 3 years of working experience. The study was done in the month of May, as during this time the work go in full swing.

The height of the subjects was measured by the Martin type anthropometric rod (manufactured by Seiber & Heignier, Switzerland) and weight by a portable, calibrated bathroom weighing scale. Blood pressure was measured with the help of Sphygomonometer and stethoscope. Three nutritional indices, i.e., Body Mass Index (BMI), Ponderal Index (PI) and Waist-hip ratio (WHR) were determined on the basis of body weight, height, waist and hip circumference measurements. Percentage of body fat (Body fat%), total body fat (kg) and lean body mass (kg) was determined by standard formulae [10]. Body types were further classified according to the International Classification of adult with reference to their BMI, as recommended by World Health Organization [11].

For dietary intake study, 30 women were selected randomly from 62 workers. The data were collected by direct food weighing technique for a period of three consecutive days for all the meals [12].

Time motion analysis was done by recording the whole day complete work cycle video on each subjects by using Sony camera (model no. HDR-XR100E). For video analysis, VLC media player software was used to determine the time sequence for each job elements.

In order to determine the job related physiological load and estimating the workers’ energy requirements, it is important to assess the energy spent during the activity and its effect on the workers’ health. The Telemetric pulmonary gas analyser instrument K4 b7 (made by Cosmed, Italy) was used to evaluate the physiological load in terms of heart rate and energy expenditure during different activities throughout the day. Energy expenditure is defined as the total amount of energy expended in different activities by an individual. The two most important components affecting energy expenditure is the type of physical activity and the time spent by an individual during activity. Thus, for estimating the daily energy expenditure, at first the detailed time spent by the workers on different types of activities during 24 hours was recorded, i.e., from the time the subject wake up in the morning till she goes to bed. Then, the energy cost per minute (kcal/min) for each type of activities was multiplied by the time spent during each activity to calculate the daily energy expenditure for that activity. The total energy expenditure for the day was then computed by summing the daily energy expenditure for all the activities.
3. RESULTS

The age and physical characteristics like body weight, height, waist circumference, hip circumference, blood pressure (systolic/diastolic), BMI, PI and WHR of the subjects were presented in Table 1. It was seen that the mean age, body weight, height and blood pressure of the subjects were 25.8 (±3.24) years, 40.4 (±2.90) kg, 151.0 (±4.31) cm and 121.1 (±15.96) mmHg / 80.1 (±9.49) mmHg respectively. While BMI and PI of the subjects are 17.7 (±1.35) kg/m² and 11.8 (±1.10) respectively WHR value was found to be 0.7 (±0.09). The values of body fat%, total body fat and lean body mass were found to be 24.7 (±0.73), 9.9 (±0.70) kg and 30.4 (±2.28) kg respectively.

Table 2 showed distribution of women workers according to body types. It was observed that out of 62 subjects, only 19 workers (30%) fall under normal category of BMI, while around 13% of the sample population were under severely thin category with Grade III chronic energy deficiency (CED) as recommended by WHO [11]. 24 workers (39%) and 11 workers (18%) fall under mild thin category (CED Grade I) and moderate thin category (CED Grade IV) of BMI respectively.

The results from Table 3, revealed that the working heart rate and energy expenditure while performing the carrying activity was 123 beats/min and 4.5 kcal/min respectively. In order to determine the work related physiological demand while performing the carrying activity, the basic parameters were compared to that of the resting, and it was seen that the mean heart rates and energy expenditure is increased as the women proceeds from resting to the working activity.

The nutritive and calorific values of the food were calculated from the standard values of Indian food [12] and the whole day dietary intake is presented in Table 4. It was observed that the average energy intake for carriers were much less than the RDA [13] considering their occupational workload which falls under heavy to extremely heavy category as described later.

The average of the basic work time, pause time, rest time, household activity time and sleep time along with standard deviation for the whole day (24 hours) was presented in both Table 5 and Figure 1. Considering the whole day as 24 hours cycle, it was observed that on an average the actual working time of the workers for carrying bricks on head lasts for almost 6 hours 352.4 (±9.16) min, with 2 hours pause 120.0 (±4.64) min and 4 hours rest 240.2 (±5.51) min interval. Almost 4 hours 243.6 (±5.74) min is spent by the workers in household activities like taking care of babies, cooking food, washing clothes, eating, washing utensils etc. followed by approximately 8 hours 482.8 (±10.24) min of sleep at the end of the day.

Table 6, showed average energy expenditure of all the activities performed throughout the day and from this the total daily energy expenditure (kcal/day) was calculated. From the table the average working, pause, resting, household activities and sleeping energy expenditure was found to be 4.5 (±0.36) kcal/min, 1.4 (±0.12) kcal/min, 1.0 (±0.09) kcal/min, 1.6 (±0.12) kcal/min and 0.8 (±0.08) kcal/min respectively. The average total energy expenditure of the day was computed by multiplying the energy expenditure of all the activities with duration of time and it was found to be 2786.5 (±101.76) kcal/day. Thus, it is seen that there is a negative energy balance of 382.8 kcal/day, which should be taken by the subjects to meet the need of the body to sustain in this extremely heavy type of job for a longer period of time.

From Figure 1, it was observed that the actual work time is divided into 4 phases namely loading time 40.1 (±2.69) mins, walking time 115.7 (±3.06) mins with 8 to 10 bricks on head, unloading time 60.9 (±4.12) mins and returning time 135.7 (±6.50) mins. During carrying bricks the maximum time 8% and 9% of the total work time is spent by the workers in walking to and from the kiln, with or without load respectively. Pause time (8%) is the time when the workers wait for her time to come during loading and unloading of bricks. 34% of the time is spent as sleeping time, followed by rest and household activity time of 17% each. This completes the 24 hours cycle of the day.

4. DISCUSSION

The mean values of weight and height of the women workers with respect to their age were found to be lower than the standard reference value of rural population for India [14,15]. Although the mean blood pressure of the subjects was found to be normal in context to normal healthy women of age 20 to 24 years. In the present study, the mean BMI for the subjects was found to be 17.7 (±1.35) kg/m², which is an indicator of the possible high risk for health complications [16]. Only 30% of the sample population belonged to normal range of BMI (18.50–22.99 kg/m²) and around 70% was under the underweight category (BMI <18.49 kg/m²) in which 13%, 18% and 39% of workers fall under severely thin, moderate thin and mild thin category respectively with reference to their BMI as recommended by WHO [11]. The risks of being underweight may be due to malnourishment, pulmonary disease, digestive problems, osteoporosis etc. From the mean value of the PI 11.8 (±1.10), it was observed that all women belonged to Ectomorphic group with value < 2.15 and having a thin and linear appearance with narrow hip and shoulder. Low PI is associated with decreased muscle strength and fatigue resistance as seen in college-aged women [17]. The mean WHR is 0.7 (±0.09), which does not indicate any possible risk, as the standard cut-off for WHR is > 0.82 for women [18]. Height, body weight, BMI and WHR are important parameters to study the genetic structure and prediction of risk factors of many complex diseases in human health [19]. It was seen that the body fat% and total body fat was less in the overall sample population compared to the value for an Indian farm woman of age 22 to 60 yrs which is 27% and 13.4 kg respectively although both population belongs to same socio economic status [20].

The workers are involved in this brick carrying activity for approximately 10 to 12 hours in a day including rest and pause time. They worked for 7 days in a week with no off day in between. Each unbaked brick they carry weighs about 3.5 to 4.0 kg and each baked brick weighs about 3.2 to 3.5 kg. On an average they carry 8 to 10 bricks per turn on head. This leads to a total load handling equivalent to 35 to 40 kg. In order to estimate the occupational workload while working, the heart rate and energy expenditure responses of the workers during the carrying activity was classified according to Varghese et al. [9], and it was observed that brick carrying activity falls under heavy to extremely heavy job category. A steep rise was noticed in the delta heart rate and energy expenditure, which attributed to the fact that during this activity, the energy expended and heart rate response of the female workers was much higher which might be due to combination of two basic factors like loading the
bricks on head in squatting posture demand a lot of core strength and walking on a slope demanding good amount of additional muscular activities for postural corrections.

Food habits of an individual are profoundly influenced by socioeconomic condition, availability of food, personal, regional and situational factors. The data showed that the subjects consumed very inadequate quantity of cereals, leafy vegetables, milk and animal products. The lower calorie intake might also be the reason for their poor physical characteristics as indicated in Table 1. The nutrient intake of the workers should be improved with increase in the consumption of leafy vegetables, fruits, milk and dairy products which contain a large amount of retinol, iron and are major sources of calcium. Through the data of the diet survey, the average energy consumed by the workers in the day was found to be 2403.8 (±156.78) kcal/day. However considering the job to be a heavy to extremely heavy in nature the energy consumption should be 2850.0 kcal/day [13]. Thus it is seen that there is a negative energy difference of 447 kcal/day which should be consumed more by the workers regarding the nature of the job. However, it was observed that the energy requirement for an Indian women, performing exceptionally active job to be 2925 kcal/day [21].

Work rest cycle showed that the time taken by the workers during ongoing path is less than that of the returning path, which might be due to the load on their head while going inside the klin was so heavy that they walk with a faster speed to release the load as soon as possible. But while coming back (i.e., return path) they either take some rest or leisurely walk in a slow pace to regain strength for the next trip. The present study also showed that they take very short rest interval compared to the workload. However, if the task duration is more, appropriate rest allowances should be taken. The total energy expenditure of the day was found to be 2786.5 (±101.76) kcal/day, which is less than that of FAO/WHO/UNU recommendations [22]. According to FAO/WHO/UNU recommendations, the average energy expenditure of a reference women of body weight 55 kg and exceptionally active is 2850 kcal/day. This negative energy difference might be due to less body weight (40.4 kg) of the sample population. For an individual to live a healthy life, equilibrium between the energy intake and energy expenditure should be maintained. But, in the present study it was found that although the energy expenditure of the job is 2786.5 kcal/day, the women workers intake 2403.8 kcal/day with a deficit of 382.8 kcal/day.

5. CONCLUSION
The findings of the present study indicated that 70% of the sample population was under thin body type category with reference to their BMI. Likewise, both the body fat % and lean body mass were also significantly less in the overall sample population. From the view point of nutritional anthropometry, most of the women were thin and skinny which revealed that these women were living in a state of great deprivation due to poor socio-economic status. The reduced body weight might attributed to the decrease in the muscle mass in response to reduced amount of protein intake as well as decline in number and size of muscle fibres due to degenerated diseases associated with aging. It may partly be due to the bones becoming lighter because of gradual mineral mass loss. The lesser skin fold thickness at different body sites may be attributed to decrease in subcutaneous fat as a result of reduced energy intake, as fat content is dependent on nutrition intake and energy expenditure. Therefore, it can be said that diet of women is deficient in terms of energy and nutrients which is reflected in decreased physical work capacity. Workers possess many occupational health hazards which are negatively correlated with their nutritional status in terms of BMI. Based on the comparison of jobs classification, it is deduced that the carrying activity was a strenuous activity and hence falls under the heavy to extremely heavy activity type. Time-motion analysis revealed that women spent most of their time and energy in brick carrying activity followed by household activities. The negative energy balance of 382.8 kcal/day might also be the reason for the poor physical characteristics. In this backdrop, it is necessary for the workers to consume balanced diet, choosing a wide variety of foods and drinks from all the food groups, at the RDA level. Nutritionist should be consulted to make the diet plan which will include local and seasonal food grains available in the local market. Simultaneously, an urgent need is necessary to create awareness and importance in this issue. Strategies should be taken to combat the malnutrition among the community at large, and the women in particular.

6. ACKNOWLEDGEMENT
We are highly thankful to DST, New Delhi for providing financial assistance to carry out this research process. We express our sincere gratitude to Prof G.G. Ray, IDC, IIT Bombay, for his continual guidance, support, valuable time & encouraging interest in this domain.

REFERENCES

Tables:

**Table 1. Physical characteristics of the women engaged in brick carrying (n=62).**

<table>
<thead>
<tr>
<th>Variables</th>
<th>mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>25.8±3.24</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>40.4±2.90</td>
</tr>
<tr>
<td>Stature (cm)</td>
<td>151.03±4.31</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>63.5±6.17</td>
</tr>
<tr>
<td>Hip circumference (cm)</td>
<td>85.5±7.65</td>
</tr>
</tbody>
</table>

**Blood Pressure (mmHg)**

| Systolic pressure         | 121±15.96 |
| Diastolic pressure        | 80±19.49  |

**Nutritional Indices**

| BMI (kg/m²)               | 17.7±1.35  |
| PI                        | 11.8±1.10  |
| WHR                       | 0.7±0.09   |
| Body Fat %                | 24.7±0.73  |
| Total body fat (kg)       | 9.9±0.70   |
| Lean body mass (kg)       | 30.4±2.28  |

**Table 2. Distribution of women workers according to body types (n=62).**

<table>
<thead>
<tr>
<th>Classification</th>
<th>BMI (kg/m²)</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CED Grade III (severe thinness)</td>
<td>&lt;16.00</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>CED Grade II (moderate thinness)</td>
<td>16.00 - 17.00</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>CED Grade I (mild thinness)</td>
<td>17.00 - 18.49</td>
<td>24</td>
<td>39</td>
</tr>
<tr>
<td>Normal</td>
<td>18.50 - 22.99</td>
<td>19</td>
<td>30</td>
</tr>
</tbody>
</table>

**Table 3. Different physiological parameters related to brick carrying (n=62).**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Resting (mean±SD)</th>
<th>Working (mean±SD)</th>
<th>Δ (mean±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>heart rate (beats/min)</td>
<td>74.7±6.61</td>
<td>123.8±11.12</td>
<td>47±4.5</td>
</tr>
<tr>
<td>Energy Expenditure (kcal/min)</td>
<td>1.0±0.09</td>
<td>4.5±0.36</td>
<td>2.83±0.23</td>
</tr>
</tbody>
</table>

where, Δ = Working data – Resting data
Table 4. Daily nutrient intake of the women (n=30).

<table>
<thead>
<tr>
<th>Serial. No.</th>
<th>Nutrient</th>
<th>Carrier (mean±SD)</th>
<th>RDA for Heavy job</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Carbohydrate (gm)</td>
<td>516.5±40.64</td>
<td>-</td>
</tr>
<tr>
<td>2.</td>
<td>Protein (gm)</td>
<td>41.8±6.93</td>
<td>50.0</td>
</tr>
<tr>
<td>3.</td>
<td>Fat (gm)</td>
<td>18.9±1.90</td>
<td>30.0</td>
</tr>
<tr>
<td>4.</td>
<td>Calcium (gm)</td>
<td>161.3±6.92</td>
<td>600.0</td>
</tr>
<tr>
<td>5.</td>
<td>Phosphorus (mg)</td>
<td>824.9±53.78</td>
<td>-</td>
</tr>
<tr>
<td>6.</td>
<td>Iron (mg)</td>
<td>10.4±0.55</td>
<td>21.0</td>
</tr>
<tr>
<td>7.</td>
<td>β-Carotene (mg)</td>
<td>592.5±57.23</td>
<td>4800.0</td>
</tr>
<tr>
<td>8.</td>
<td>Thiamine (mg)</td>
<td>1.0±0.20</td>
<td>1.4</td>
</tr>
<tr>
<td>9.</td>
<td>Riboflavin (mg)</td>
<td>0.6±0.11</td>
<td>1.7</td>
</tr>
<tr>
<td>10.</td>
<td>Niacin (mg)</td>
<td>8.9±0.93</td>
<td>16.0</td>
</tr>
<tr>
<td>11.</td>
<td>Ascorbic acid (mg)</td>
<td>12.3±0.99</td>
<td>40.0</td>
</tr>
<tr>
<td>12.</td>
<td>Total energy consumed (kcal/day)</td>
<td>2403.8±156.78</td>
<td>2850.0</td>
</tr>
</tbody>
</table>

Table 5. Average of whole day time motion analysis (mean±SD).

<table>
<thead>
<tr>
<th>Actual work time (min)</th>
<th>Pause time (mins)</th>
<th>Rest time (mins)</th>
<th>Household activity time (mins)</th>
<th>Sleep time (mins)</th>
<th>Grand total time (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading time</td>
<td>40.1±2.69</td>
<td></td>
<td></td>
<td>482.8±10.24</td>
<td>1439.0±15.99 (approx.)</td>
</tr>
<tr>
<td>Walking time</td>
<td>115.7±3.06</td>
<td>120.0±4.64</td>
<td>240.2±5.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unloading time</td>
<td>60.9±4.12</td>
<td>240.2±5.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Returning time</td>
<td>135.7±6.50</td>
<td>243.6±5.74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>352.4±9.16</td>
<td>243.6±5.74</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Average Energy expenditure of whole day (n=62).

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Activities</th>
<th>Energy expenditure (kcal/min)</th>
<th>Energy expenditure (kcal/day)</th>
<th>Total Energy expenditure (kcal/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Working</td>
<td>4.5±0.36</td>
<td>1590.5±139.32</td>
<td>2786.5±101.76</td>
</tr>
<tr>
<td>2.</td>
<td>Pause</td>
<td>1.4±0.12</td>
<td>168.3±19.37</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Rest</td>
<td>1.0±0.09</td>
<td>251.7±21.5</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Household activities</td>
<td>1.6±0.12</td>
<td>389.7±30.94</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Sleep</td>
<td>0.8±0.08</td>
<td>386.4±41.54</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Pie chart of proportionate time representation of different job element throughout the day (n=62).
The Indian brick industry is an unorganized sector in which large numbers of migrant women workers are employed. A survey was conducted on 62 women workers working in different brickfields of West Bengal to assess their physiological workload, nutritional profile, total energy expenditure and energy balance. Energy intake was calculated using physiological fuel values of carbohydrate, fat and protein. From the results it is seen that 13% of the sample population falls under severe (grade III) chronic energy deficiency. The average daily consumption of the workers was comparatively lower than their daily energy expenditure, considering the nature of the job which falls under heavy to extremely heavy categories. This negative energy balance is effectively observed in the nutritional anthropometry data. Thus, an immediate ergonomics intervention with better nutrition should be implemented to improve the health status of the workers so they can safely continue to work for a longer period.

Keywords: brickfield, carriers, nutrition, heart rate, energy expenditure, energy balance
Occupational Stress among Women Moulders: A Study in Manual Brick Manufacturing Industry of West Bengal

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Abstract - Manual brick manufacturing is an age-old profession practiced all over the world and brick is a very important building material for a developing country, especially like India to improve infrastructure. Women have become an integral part of manpower resources in these unorganized sectors, but unfortunately the female workers here suffer a silent agony. The present study examines the occupational profile, impact of work factor in terms of physiological, biomechanical, musculoskeletal and psychosocial discomforts prevalence among workers in brick kilns. A study was conducted on female moulders engaged in different brick-kiln of West Bengal. Physical parameters such as body weight, height, grip strength; occupational status based on socioeconomic profile; physiological parameters like pulmonary status, biomechanical assessment; and psychosocial assessment were studied. From the result it is seen that 18% of the sample population falls under severe Grade III chronic energy deficiency. More than 90% of body pain is felt in wrists, back, both knees, both thighs and both ankles due to the awkward postures adopted by them. Postural assessment by REBA, RULA and OWAS method shows that most of the posture adopted during work should be corrected immediately. Majority of the workers are in the borderline tending towards development of Chronic Obstructive Pulmonary Disease. The workers worked for more than 8 hours per day, with very less monthly income. Long working hours without adequate rest, low wages, job insecurity and bullying by superiors contribute to various physiological and psychosocial stress which in turn tends workers to various addictive behaviors. Thus, immediate ergonomic interventions are required to improve the quality of life of these workers so that they can continue working for a longer period under the conducive and safe work condition which in turn will influence the social security, health and safety of the workers.

Index Terms - Brick-kiln, women workers, moulders, unorganized sectors, posture.

I. INTRODUCTION

The Indian brick industry is an age old unorganized sectors and the second largest in the world employing large numbers of migrant women workers (Khan & Vyas, 2008). The industry has an annual turnover of more than 10000 crores and it is one of the largest employment generating industries (Khan & Vyas, 2008). In the developed countries some mechanization was introduced but in India the conditions have not improved and human drudgery still prevails. Various studies showed that the workers working in the brick manufacturing units suffered from musculoskeletal problems due to awkward working postures (Heuer et al., 1996; Chung & Kee, 2000; Trevelyan & Haslani, 2001). Studies from developing countries like India, shows that these workers suffer from assorted health problems due to handling of heavy loads without taking adequate rest breaks (Mukhopadhyay, 2008; Sett & Sahu, 2008). Moreover, some studies had reported that women had a higher prevalence rate of work-related musculoskeletal disorders (MSDs) to that of men (Treater & Burr, 2004; Basu et al., 2008). Work-related MSDs are common causes of pain and functional decline which in turn lead to significant distress and disability (Rempel et al., 1992; Shaw et al., 2002). Various risk factors are involved including biomechanical and environmental conditions such as physical work load, unfavorable body posture, vibration, psychosocial factors such as time, pressure and repetitive or monotonous tasks (Ariens et al., 2000; Bongers et al., 2002; Cromie et al., 2002; Salerno et al., 2002). Although advancement in mechanization has greatly reduced physical stress on the brickfield workers, it still remains the most physically demanding occupation (Gallagher, 1999). Therefore, a field study was conducted on female laborers working in several manual brick manufacturing units of West Bengal, to understand the nature of work, analyze their socio economic status, find out the occupational stress on the workers and to give some suggestive remedial measures for humanizing working condition of brick workers. The process of brick making involves several steps of which, moulding is one of the essential part performed by a group of workers designated as ‘moulders’.

II. METHODOLOGY

A. Selection of site and subjects.

The brickfields under study were situated around Uttarpara (District Hooghly) and Dhibdhibi (District South 24 parganas). 55 brick moulders with mean age of 24.4± 4.16 years and having minimum 2 years of working experience was randomly selected for the study. The volunteers were selected with no history of chronic or acute illness, not having hypertension, no acute rheumatic problem, not currently consuming any medicine and not pregnant. The study was done in the month of March and April, as during this time the work go in full swing.

B. Assessment of physical characteristics

The height of the subjects was measured by the Martin type anthropometric rod (mfg by Seiber & Heignar, Switzerland) and weight by a portable, calibrated bathroom weighing machine.
Hand grip strength was determined by using a hand grip dynamometer (Inco, Ambala, India) to test the maximum voluntary contraction (Ravishankar et al., 2005). The best of three trials were accepted with three minutes rest in-between (Chien et al., 2002).

C. Occupational profile of the women workers
An interview schedule was constructed for collecting several data like the nature of employment, duration of employment, daily working hours and monthly income by means of questionnaire.

D. Occurrence of occupational health problems related to Physiological factors.
   i). Biomechanical analysis - Work posture assessment
   Complete work cycle video were recorded on each subjects by using Sony camera (model no. HDR-XR100E) which was fixed on the tripod. Working postures was then evaluated and analyzed by the following methods:
   - RULA method (Rapid Upper Limb Assessment) (McAtamney & Corlett, 1993).
   - REBA method (Rapid Entire Body Assessment) (Hignett & McAtamney, 2000).

   ii). Nordic Questionnaire study and Subjective methods of discomfort
   Modified Nordic questionnaire study was done for knowing the occurrence or frequency of pain felt in different parts of their body due to posture at work (Kuorinka et al., 1987). The intensity of pain was measured by modified Body Part Discomfort (BPD) scale. The scale consists of Grade from 0 to 3, with Grade 0 signifies no discomfort at all, Grade 1 signifies just noticeable discomfort, Grade 2 signifies moderate discomfort and Grade 3 signifies intolerable discomfort. As most of the volunteers were illiterate it was very difficult to use 5 point or 10 point scale (Corlett & Bishop, 1976), as they felt difficulty and are very confused in rating their pain in the two extreme points of the scale, as seen in pilot study. So this 3 point scale was used which they feel comfortable.

   iii). Assessment of Pulmonary status
   To evaluate the lung function capacity, Lung Function test was performed by using automatic Lung function machine & software (Kokko, Finland). Subjects were asked to take a deep inspiration. While breathing out, they were instructed to expire through a connecting tube with maximum effort to continue for 6 sec without any inspiration. From the graph, the Forced vital capacity (FVC) and Forced expiratory volume at 1.0 sec (FEV1.0) were collected. The volumes were expressed in terms of Body Temperature, Pressure and Saturated (BTPS) condition.

E. Occurrence of occupational health problems related to psychosocial factors.
This was assessed by means of questionnaire study. Data were collected by using pre tested interview schedule.

III. RESULTS AND DISCUSSION

Table I: Physical Characteristics of the sample population (n=55)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>24.4± 4.16</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>39.6±3.44</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>149.0± 4.62</td>
</tr>
<tr>
<td>Body Mass Index (BMI) kg/m²</td>
<td>17.9±1.80</td>
</tr>
<tr>
<td>Ponderal Index (PI)</td>
<td>12.0±1.43</td>
</tr>
<tr>
<td>Maximum grip strength in Left hand (kg)</td>
<td>24.6 ± 3.96</td>
</tr>
<tr>
<td>Maximum grip strength in Right hand (kg)</td>
<td>25.0 ± 4.06</td>
</tr>
</tbody>
</table>

The physical characteristics of the brick kiln workers were presented in Table I. The mean body weight of the sample population was found to be less with reference to their age and height (Rao & Balakrishna, 1995). According to the World Health Organization (WHO), there is a very simple relationship between BMI and the risk of the simultaneous presence of two chronic diseases or conditions in a patient (co-morbidity), in which a normal range of BMI is considered to be between 18.5 and 22.9 kg/m² in Indian women (Das & Bose 2010). In the present study, the mean BMI for the subjects was found to be 17.9 kg/m² which is indicative of the possible high risk for health complications (WHO, 2004).
It was observed that out of the 55 subjects, 42% fell in the normal category while rest 58% of the women fell in the underweight category, in which 18% of the sample population was under severely thin Grade III chronic energy deficiency with BMI < 16 kg/m² as recommended by WHO (Figure 1). The risks of being underweight may be due to malnourishment, compromised immune function, respiratory disease, tuberculosis (an infection of the lung), digestive (stomach) disease, cancer, osteoporosis etc. Result from the Ponderal Index showed that the majority of the women belonged to the Ectomorphic group with value < 21.5 and having a thin, linear appearance with narrow waist, hips and shoulders.

Table II. Occupational profile of the women workers (n=55)

<table>
<thead>
<tr>
<th>Occupational details</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of occupation</td>
<td>55</td>
<td>100.00</td>
</tr>
<tr>
<td>Temporary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of employment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 3 years</td>
<td>8</td>
<td>14.55</td>
</tr>
<tr>
<td>3-5 years</td>
<td>29</td>
<td>52.73</td>
</tr>
<tr>
<td>Above 5 years</td>
<td>18</td>
<td>32.73</td>
</tr>
<tr>
<td>Daily working hours</td>
<td>55</td>
<td>100.00</td>
</tr>
<tr>
<td>Monthly income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 2000 rupees</td>
<td>51</td>
<td>92.73</td>
</tr>
<tr>
<td>≥ 2000 rupees</td>
<td>4</td>
<td>7.27</td>
</tr>
</tbody>
</table>

The occupational profile of the women workers based on socioeconomic profile is shown in Table II. All the women workers engaged in temporary jobs thus it is very clear that the industry did not provide any job security. The total duration of the employment is about 3 to 5 years. All the women worked for more than 8 hours per day, with monthly income of less than Rupees 2000. Wages are paid on the basis of the number of bricks made by them.

Table III. Postural assessment of the brick moulders

<table>
<thead>
<tr>
<th>Postures</th>
<th>OWAS code</th>
<th>Action level</th>
<th>RULA score</th>
<th>Action level</th>
<th>REBA score</th>
<th>Action level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting mud</td>
<td>2,1,6,1</td>
<td>Corrective measures in near future</td>
<td>7</td>
<td>Investigate and change immediately</td>
<td>12</td>
<td>Very high risk, implement change</td>
</tr>
<tr>
<td>Inserting mud in mould</td>
<td>2,1,6,1</td>
<td>Corrective measures in near future</td>
<td>7</td>
<td>Investigate and change immediately</td>
<td>10</td>
<td>High risk, investigate &amp; implement change</td>
</tr>
<tr>
<td>Take out brick from mould</td>
<td>4,1,6,1</td>
<td>Corrective measures in near future</td>
<td>7</td>
<td>Investigate and change immediately</td>
<td>12</td>
<td>Very high risk, implement</td>
</tr>
</tbody>
</table>

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Change

Posture of work is the body positioning required during the performance of work. The entire process of manual brick moulding was divided into certain components for postural assessment as shown in Table III. Different standardized methods were applied for each component to identify the risk factors associated with a particular task. Cutting mud, inserting mud into the mould and take out brick from the mould, were the main task components. Assessment by OWAS method revealed that all the postures were highly risky and corrective measures were required as soon as possible. In every stages of brick moulding, RULA score of 7 with action level 4 suggested interventions and changes are immediately required. REBA score was 10 or more than 10 in all the postures indicating corrective action including further assessment is immediately required. Based on postural evaluation scores from the above table it was clear that adoption of sustained squatting posture and moulding the bricks by forward bending, for hours after hours throughout the day, is very detrimental for the workforce. It was evident from the result that prolonged sitting in squatting posture caused numbness in the lower leg resulting from lack of blood supply due to sustained muscle compression, which in turn leads to MSDs and ultimately injury to different body parts. Changes in work posture by implementing better work station and associated tools need immediate attention.

![Percentage of pain](image)

**Figure 3: Job related body pain as reported by the volunteer group**

Job related body pain by Nordic questionnaire as reported by the volunteer group is given in Figure 3. It was observed that more than 90% of body pain were felt in wrists, upper back and lower back, both knees, both thighs and both ankles. Thus it was seen that the brick moulders had more pain in the wrists and lower part of the body compared to upper part, because most of the time they use to sit continuously in the same awkward squatting posture for long hours to mould the bricks without taking frequent rest interval.

<table>
<thead>
<tr>
<th>Body Parts</th>
<th>No. of subjects</th>
<th>Body Part Discomfort Scaling</th>
<th>Grade 0</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>26</td>
<td>-</td>
<td>2</td>
<td>17</td>
<td>65.38%</td>
<td>7</td>
</tr>
<tr>
<td>Neck</td>
<td>47</td>
<td>-</td>
<td>-</td>
<td>15</td>
<td>31.91%</td>
<td>32</td>
</tr>
<tr>
<td>Both Shoulders</td>
<td>40</td>
<td>-</td>
<td>-</td>
<td>8</td>
<td>20.00%</td>
<td>32</td>
</tr>
<tr>
<td>Both Elbows</td>
<td>42</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>9.52%</td>
<td>38</td>
</tr>
</tbody>
</table>

Table IV. Body Part Discomfort Scaling (BPD) Scale (n=55)
The intensity of pain or discomfort measured by Body Part Discomfort (BPD) scale is shown in Table IV. The result from the present study shows that 87.89% of the women workers experience severe pain and 11.78% workers feel moderate pain due to strenuous posture at work. It was seen that more discomfort zones were concentrated to the whole body especially in the both arms and lower part of the body. Most of the workers suffers pain in intolerable range (grade 3), as the brick moulders go on moulding in the same awkward sitting posture for long hours and their task is designated as repetitive in nature contributing to their major discomfort level.

**Table V. The Pulmonary parameters of brick moulder (n=55)**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forced vital capacity FVC (lit)</td>
<td>2.1±0.60</td>
</tr>
<tr>
<td>Forced expiratory volume at 1.0 sec FEV1.0 (lit)</td>
<td>1.5±0.41</td>
</tr>
<tr>
<td>% FEV1.0/FVC</td>
<td>74.4±9.85</td>
</tr>
</tbody>
</table>

Physiological strain in the female moulders is expressed in Table V. It was observed that the workers work in a very dusty environment for long hours without taking adequate rest. According to the National Institute of Clinical Excellence, the diagnosis of Chronic Obstructive Pulmonary Disease (COPD) is made when the %FEV_{1.0}/FVC ratio is less than 70. The result shows that the mean %FEV_{1.0}/FVC is 74, so the workers are in the borderline tending towards development of COPD. The exposure towards dust and smokes in the field area might be the reasons for this.

Table VI. Frequency of Occupational Health problems related to psychosocial factors (n=55)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>32</td>
<td>58.18</td>
</tr>
<tr>
<td>Depression</td>
<td>35</td>
<td>63.64</td>
</tr>
<tr>
<td>Frustration</td>
<td>37</td>
<td>67.27</td>
</tr>
<tr>
<td>Worry</td>
<td>23</td>
<td>41.81</td>
</tr>
<tr>
<td>Low self esteem</td>
<td>33</td>
<td>60.00</td>
</tr>
<tr>
<td>Boredom</td>
<td>19</td>
<td>34.55</td>
</tr>
<tr>
<td>Lack of sleep</td>
<td>25</td>
<td>45.45</td>
</tr>
</tbody>
</table>

Frequency of occurrence of Occupational Health problems related to psychosocial factors is shown in Table VI. From the result it was observed that 58% of the women workers experienced headache due to long working duration in awkward posture. The other problems felt were frustration, lack of sleep and boredom. Upadhaya (1980) reported that the heath and efficiency of the workers depends on the number of hours they have to work. In case of long working hours, the workers are bound to be tired and slacken in their duties. Job security is the
A sense of guarantee of not losing the job. Due to temporary nature of the job 60% of women workers always felt that their self-esteem was hurt.  The other frequent problems faced were frustration, depression and worry. Selvarani (1992) reported that lack of job security aggravates mental health problems and employers make use of this sort of insecurity to exploit workers.

**Table VII. Frequency of different modes of addiction (n=55)**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chewing</td>
<td>52</td>
<td>94.55</td>
</tr>
<tr>
<td>Smoking</td>
<td>15</td>
<td>19.35</td>
</tr>
</tbody>
</table>

Long working hours without adequate rest, low wages, job insecurity and bullying by superiors contributed to these various psychosocial stresses. Both physiological and psychosocial stress tends workers to various addictive behaviors like smoking, chewing tobacco etc. as shown in Table VII.

**IV. CONCLUSION**

Thus the physiological evaluation provided an understanding that the ailments of the women workers are multifactorial and the health problems are positively associated with biomechanical, psychosocial, nutritional, clinical and pulmonary aspects. Biomechanical analysis indicated that the workers are constantly adapting awkward postures, such as, squatting, bending and lifting of load on their hands which resulted in severe back pain and constant aches in the upper and mainly in lower extremities of their body. From the view point of nutritional status, most of the women were thin and skinny. Prevalence of clinical deficiency signs is pronounced in majority of the women. Emphasis needs to be given on improving their eating patterns through dietician’s suggestion and nutrition awareness programs which will ultimately improve their physical efficiency. Lung function study revealed that lung efficiency is less than normal in most of the women workers under study. Though at present no supporting clinical evidences was obtained but if the respiratory protection kits are not introduced, this might lead to serious respiratory disorders in the long run. Thus there is also a requirement of awareness program in parallel to the community. It is needless to mention that the importance lies in a systematic intervention between the designer and the users to attain a safer, comfortable work condition. In contrary, the management should stipulate the personal protective equipment required for the specific activity to be performed and ensure that the workers abide by these stipulations. It is important to create awareness of occupational health hazards both to the workers and the management, considering the literacy level and socio-economic condition.

**V. RECOMMENDATIONS**

Considering most of the workers being illiterate, awareness campaign on safe work practices should be developed for making the workers aware about the impact of the job on personal health. Proper rotation of duty, proper shift system, yoga and physical exercises should be introduced to reduce boredom, frustrations, stress and anxiety. Ergonomics and safe practices to do work have to be established to reduce work related vulnerabilities and thereby increasing over all wellbeing of workers. The workers should be aware how to use the work related tools and protective aids. Organization should be aware of better workplace layout to minimize movements, twisting and asymmetrical lifting or lowering. Re-scheduling of work should be done to allow short breaks for muscle recovery, especially if the workers perform some stretching exercises. Nutritional status of the workers may be related to the prevalence of work related health problems. Nutritional status must be improved by proper counseling of food habits and maintaining hygienic condition to reduce musculoskeletal disorders of the workers. Last but not the least employers must pay attention to the human aspect and promote worker’s development by better payment and incentives.

**ACKNOWLEDGMENT**

We are highly thankful to DST, New Delhi for providing financial assistance to carry out this research process. We express our sincere gratitude to Prof G.G. Ray, IDC, IIT Bombay, for his continual guidance, support, valuable time & encouraging interest in this domain.

**REFERENCES**


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Paper ID220 (Vol. I, Page 539): Designing of Mould for Brickfield Workers

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IDC, IIT Bombay, Mumbai, India

Abstract Brick manufacturing is a traditional, unorganized and very booming industry in India. More than 150,000 brick units are engaged in brick making with employment to more than 8 million workers. The main drawback of existing brick moulding method is that a large amount of load is handled by fingers and wrists of both hands in squatting posture. There is wrist bending of $(32.78^\circ \pm 12.84)$ which mostly consists of ulnar deviation, which in turn causes pain in wrist movement. Thus, an ergonomic study is done for improving the hand, wrist-palms and finger movement. Three different new concepts of moulds were designed which will not only increase the productivity by delaying the physiological fatigue, but also will prevent the expense of the human cost. So that the workers can continue working for a longer period under the conducive and safe work condition which in turn will influence their social security, health and safety.
User Centered Design and Occupational Wellbeing

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Cardiovascular Efficiency of Brickfield Women Workers around Kolkata, West Bengal

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Abstract
The cardiovascular performance of women brick field workers working in six different brickfields around Kolkata was studied in relation to the types of work they performed. The study depicts that while the female moulders handled the load of around 6kg by their hands, the carriers carry a load of around 40kg on their head per every turn. During brick moulding and carrying activity the average working heart rate was found to be 125.7±8.6 beats.min⁻¹ and 128.1±6.6 beats.min⁻¹ respectively while the respective energy expenditure was of 4.0±0.8 kcal.min⁻¹ and 4.5±0.7 kcal.min⁻¹ and oxygen consumption was of 0.8±0.1 l.min⁻¹ and 0.9±0.1 l.min⁻¹. The average oxygen consumption was observed as 47.00 % VO₂ max and 50.37 % VO₂ max for moulding and carrying activity respectively. Based on physiological parameters it can be concluded that immediate ergonomic interventions are required to improve the quality of life of these workers by reducing the work load. This can be achieved either by improving the work posture and developing new concept tools for the moulding operation along with introducing new concept manual load carrying. This will help the workers continue working for a longer period under the conducive and safe work condition which in turn will influence the social wellbeing, health and safety of the workers.

Keywords - women, brick field, heart rate, oxygen consumption, energy expenditure.

1. INTRODUCTION
Brick manufacturing work is an age-old profession practiced all over the world and brick is a very important building material for a developing country, especially like India to improve infrastructure. Studies conducted in developing countries shows that these workers suffer from assorted health problems due to awkward postures and carrying heavy loads [1, 2]. Heart rate is one of the most accurate means of studying the energy expenditure while performing any activity. Generally heart rate is used as an easily applicable parameter to evaluate the physiological or functional demands of work on the individual worker [3]. Recent records reveal that in India very little work has been done on male workers of unorganized sector while in brickfield women workers have been totally ignored.

2. METHODOLOGY
2.1. Description of activity. The process of brick making involves several steps of which brick moulding and brick carrying are an essential part which is done by the women workers. Moulding is done by a group of workers designated as 'moulders', where a lump of mud (clay, water and salt) is taken, rolled in sand and placed in a mould in order to form specified shapes of bricks and carrying is done by a group of workers, mostly female, designated as 'carriers' who carry raw bricks from the stacks in the field to the brick kiln and baked bricks back from the kiln, to stack in some other places in the field for transport outside. Moulding and carrying are basically a repetitive and continuous work performed in awkward posture in which a high load of around 6 kg per turn and 40 kg per transfer are handled by hand and head mode during moulding and carrying activities respectively.

2.2. Selection of site and subjects. The brickfields under study were situated around Kolkata in West Bengal. A total of one hundred fifty women workers were screened for the study. Out of this one hundred thirty five women workers engaged in brick field activities were selected for the study, out of which sixty five were moulders and remaining seventy were carriers, having minimum of three years of working experiences.

2.3. Assessment of physical characteristics. The height of the subjects was measured by Martin’s anthropometric rod and weight by a portable bathroom weighing machine. Blood pressure (BP) and skinfold was measured with the help of a Sphygmomanometer, stethoscope and Herpenden Skinfold caliper respectively. Two nutritional indices, i.e., Body Mass Index (BMI) and Ponderal Index (P.I.) were determined on the basis of weight and height measurements.
2.4. Environmental parameters. To understand the amount of heat stress (Thermal load) imposed on the body of the workers while working in brick field, the Corrected Effective Temperature (CET) and Wet Bulb Globe temperature (WBGТ) indices were determined.

2.5. Energy expenditure. In order to determine the job related physiological workload and estimating the workers’ energy requirements, it was important to assess the energy spent by them during activity and its possible impact on the workers health. Attempt was made to find out the energy expended from the corresponding heart rate (HR) while performing the job by the women workers in brick moulding and carrying activity at the brick field. This helped in assessing the heaviness of the job during load carrying. The study was conducted in the brick fields in the natural conditions to avoid any discomfort of unfamiliar situation. The Telemetric Oxygen Gas Analyzer instrument K4b2 (made by Cosmed, Italy) was used to measure the various physiological parameters during the carrying activity in the field as shown in fig. 1(a) and 1(b).

![Figure 1(a). Moulders working with K4b2 system.](image1)

![Figure 1(b). Carriers working with K4b2 system.](image2)

2.6. Determination of maximum aerobic capacity. VO$_2$ max was determined on 20 brick field women workers by treadmill (Venky Treadmill, S.T.D. Model no. AETM-002). O$_2$ consumption was determined using the Telemetric K4b2 (made by Cosmed, Italy) gas analyser. The VO$_2$ max study was done maintaining the following protocol. The experimental set-up is depicted through Fig 2.

![Figure 2. Determination of maximum aerobic capacity in a treadmill.](image3)

The resting HR (beats.min$^{-1}$), BP (mm Hg) and O$_2$ con (L.min$^{-1}$) in the expired air were collected in sitting resting posture. Sufficient time was allotted to the subject to accustom with treadmill walking. At the beginning of this experiment, subject was asked to walk hastily on treadmill with a speed of 6 km.hr$^{-1}$ at zero grade for 5 min. After 5 min exercise the subjects were asked to walk with the same walking speed of 6 km.hr$^{-1}$ but its grade/inclination was increased in steps of 5 up to 25. In case, the subject was not exhausted completely with grade 25 and running speed of 6 km.hr$^{-1}$, the speed of treadmill was further increase in steps (1 km.hr$^{-1}$) i.e. 7 km.hr$^{-1}$, 8 km.hr$^{-1}$ and 9 km.hr$^{-1}$ keeping the grade constant at 25. This experiment was continued till the subject reached to their volitional fatigue level and they could no longer continue despite the verbal encouragement. In each case the HR (beats.min$^{-1}$), and O$_2$ con (L.min$^{-1}$) were recorded throughout. The data between 4 to 5 min of work were considered as the appropriate representative for the workload and taken into account for workload calculation purpose.

3. RESULTS

From Table 1 it can be observed that the mean age, body weight and height of the brick moulders were 24.4± (4.1) yr, 41.1± (5.1) kg, 149.6± (4.7) cm and those for carriers were 25.8 (±3.2) yr, 42.1 ± (±4.8) kg, 151.2 (±4.3) cm respectively.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Moulders</th>
<th>Carriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>24.4±4.1</td>
<td>25.8±3.2</td>
</tr>
<tr>
<td>Body Weight (kg)</td>
<td>41.1±5.1</td>
<td>42.1±4.8</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>149.6±4.7</td>
<td>151.2±4.3</td>
</tr>
<tr>
<td>Blood Pressure (mmHg)</td>
<td>124.6±12.5</td>
<td>121.1±15.9</td>
</tr>
<tr>
<td>Systolic pressure</td>
<td>82.5±8.6</td>
<td>80.1±9.4</td>
</tr>
<tr>
<td>Diastolic pressure</td>
<td>18.4±2.4</td>
<td>18.4±1.8</td>
</tr>
<tr>
<td>Nutritional Indices</td>
<td>12.3±1.8</td>
<td>12.2±1.3</td>
</tr>
</tbody>
</table>
Although the mean blood pressure of the subjects was found to be within normal range in context to normal healthy women of age 20 to 24 years, but the mean BMI and PI of the brick moulders and brick carriers was found to be less than the normal value (18.5 and 22.9 kg, (m²)¹) in both the groups which is indicative of the possible high risk for health complications [6] and showing that all women belonged to Ectomorphic group with value < 21.5 and having a thin and lean appearance with narrow hip and shoulder respectively.

Table 2. Thermal environmental conditions during study.

<table>
<thead>
<tr>
<th>Field in</th>
<th>WBGT</th>
<th>CET (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Bengal</td>
<td>32.4±2.1</td>
<td>30.5±1.7</td>
</tr>
</tbody>
</table>

The mean WBGT and CET values was found to be 32.4±2.1 and 30.5±1.7 (°C) respectively.

Table 3. Different physiological parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Moulders</th>
<th>Carriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting heart rate (beats.min⁻¹)</td>
<td>80.4 ± 6.3</td>
<td>74.6±6.6</td>
</tr>
<tr>
<td>Working heart rate (beats.min⁻¹)</td>
<td>125.7±8.6</td>
<td>128.1±6.6</td>
</tr>
<tr>
<td>Resting energy expenditure (kcal.min⁻¹)</td>
<td>1.0±0.1</td>
<td>1.0±0.1</td>
</tr>
<tr>
<td>Working energy expenditure (kcal.min⁻¹)</td>
<td>4.0±0.8</td>
<td>4.5±0.7</td>
</tr>
</tbody>
</table>

Results from the Table 3 revealed that during brick making and carrying activity the average working heart rate was found to be 125.7±8.6 beats.min⁻¹ and 128.1±6.6 beats.min⁻¹ and energy expenditure of 4.0±0.8 kcal.min⁻¹ and 4.5±0.7 kcal.min⁻¹ respectively.

Table 4. Physical characteristics and maximum aerobic capacity of brick moulders (n=10).

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>HR max (beats.min⁻¹)</th>
<th>VO₂ max (L.min⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.5±2.4</td>
<td>149.8±4.8</td>
<td>42.5±3.5</td>
<td>189.4±4.2</td>
<td>1.7±0.32</td>
</tr>
</tbody>
</table>

Table 5. Physical characteristics and maximum aerobic capacity of brick carriers (n=10).

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>HR max (beats.min⁻¹)</th>
<th>VO₂ max (L.min⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.6±3.5</td>
<td>150.1±5.2</td>
<td>43.6±4.2</td>
<td>188.6±3.8</td>
<td>1.7±0.2</td>
</tr>
</tbody>
</table>

Table 4 and 5 indicates that the average maximum oxygen consumption rate (VO₂ max) for brick moulders and carriers was found to be 1.7±0.3 L.min⁻¹ and 1.7±0.2 L.min⁻¹ respectively.

Table 6. Physiological stress of women moulders working in brick field.

<table>
<thead>
<tr>
<th>Working O₂ consumption (L.min⁻¹)</th>
<th>VO₂ max (L.min⁻¹)</th>
<th>% VO₂ max (predicted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8±0.1</td>
<td>1.7±0.3</td>
<td>47.00</td>
</tr>
</tbody>
</table>

Table 7. Physiological stress of women carriers working in brick field.

<table>
<thead>
<tr>
<th>Working O₂ consumption (L.min⁻¹)</th>
<th>VO₂ max (L.min⁻¹)</th>
<th>% VO₂ max (predicted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9±0.1</td>
<td>1.7±0.3</td>
<td>50.37</td>
</tr>
</tbody>
</table>

From above table, it can be observed that in case of brick moulding and carrying activity the average oxygen consumption was 47.00 % and 50.37 % of the respective VO₂ max for moulding and carrying activity which is of very high value in terms of sustained work activity.

Majority of the moulders complained of pain in the neck, both hands, wrists, hip and lower parts of the body after activity. This may be due to continuous sitting in awkward posture for long duration of time to mould the bricks. On the other hand, since the female brick carriers carry a heavy load to and fro within the brick kiln, they suffer more discomfort and pain in the head, neck, shoulder and also their trunk.

4. DISCUSSION

The physical characteristics of the brick kiln workers are presented in Table 1. The mean body weight of the sample population was found to be less with reference to their age and height [4]. According to the World Health Organization (WHO), there is a very simple relationship between BMI and the risk of the simultaneous presence of two chronic diseases or conditions in a patient (comorbidity), in which a normal range of BMI is considered to be between 18.5 and 22.9 kg, (m²)¹ in Indian women [5]. In the present study, the mean BMI for the subjects was found to be less than the normal value in both the groups which is indicative of the possible high risk for health complications [6]. Although the mean value of the blood pressure was found to be normal but from the mean value of the P.I it was observed that all women belonged to Ectomorphic group with value < 21.5 and having a thin and lean appearance with narrow hip and shoulder.

WBGT value was found to be higher than the permissible threshold values of 25. [7]. CET was also more than the comfort limits for the Tropics which is from 24-27°C [8]. Thus it can be said that the workers were exposed to higher thermal stress which may reduces the work performance (reduces productivity) by excessive
loss of water from the body which in turn affects the health of the work force.

The women workers worked for 7 days in a week for approximately 10 to 12 hours in a day including rest and pause time, with no off day in between. In order to estimate the occupational workload while working, the heart rate and energy expenditure responses of the workers during the carrying activity was classified according to Varghese et al. [9]. However it was observed that, although according to heart rate the brick moulding and carrying activity falls under heavy job category but according to energy expenditure both the job falls under extremely heavy category.

As per the classification of Saha et al 1996 and Varghese et al. 1996, the fitness level of the brick moulders and carriers as observed in this study fall under the very good category [9, 10]. However, according to the classification by Heyward (2006) of women from age group 20 to 29 years, the fitness level of the women workers fall under the fair category [11].

Although in both the cases the resting heart rate was between 74 to 80 beats. min\(^{-1}\) but the working heart rate went above 120 beats. min\(^{-1}\). This clearly indicates that all the workers were working with a cumulative physiological stress due to insufficient recovery time which was also supported by the complaint of higher rates of body ache and feeling of tiredness towards the end of the day. Workers also reported that body pain persisted on the next day. Besides the work these workers have to do household work like cleaning utensils, washing clothes, water carrying and also take care of their children. Few receive help from other members of the family.

5. CONCLUSION

From the view point of nutritional anthropology, most of the women were thin and skinny which revealed that these women were living in a state of great health related deprivation due to poor socio-economic status. The reduced body weight might be due to poor nutritional intake. Based on the comparison of jobs classification, it is deduced that the manual brick making and carrying activity in brick making industry was a strenuous activity and hence falls under the heavy activity type. By looking at the % VO\(_2\)max values it can be said that in both the cases the work was performed under considerable amount of physiologically stressful condition which also imposes a large amount of physiological stress on the body. However from the % VO\(_2\)max values it can be said that in comparison to the moulding activity, carrying activity is a heavier job, demanding more physiological cost. This might be due to carrying more loads at a higher walking speed.

Thus, immediate ergonomic interventions are required to improve the quality of life of these workers by reducing the work load either by improving the work posture and developing new concept tools for the moulding operation and by reducing the amount of load to be carried on head mode, so that they can continue working for a longer period under the conducive and safe work condition which in turn will influence the social security, health and safety of the workers. Incorporation of assistive tools/methods should further be encouraged for manual transfer of load.

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AC51

LOAD CARRYING IN TWO DIFFERENT MODES BY THE BRICK KILN WORKERS – A COMPARATIVE ANALYSIS.
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*Research Scholar, Presidency University, Kolkata; **Research Scholar, IDC, IIT Bombay, Mumbai;
***Project Assistant, IDC, IIT Bombay, Mumbai; ****Professor, IDC, IIT Bombay, Mumbai

Indian brick industry is the second largest in the world employing large numbers of migrant women workers. Brick carrying activity is a part of the entire brick making operation, which is performed by groups of workers designated as ‘carriers’ working under extreme adverse work conditions including physical environment and poor logistic support. The carriers carry raw bricks (weight 3.5 kg per brick) from the stacks in the field to the brick kiln and baked bricks (each brick weighing around 3.0 kg) from the kiln, to stack in some other places in the field for export. In average the total number of bricks carried by the carriers is 10 bricks per trip in Kolkata, by head mode (HM), and 40 bricks per trip in Ahmedabad by using a wheel barrow (WBM). This leads to a total load handling around 35 kg in HM and 140 kg in WBM. The physical status (anthropometry) of the workers, work postures adopted during job (REBA, RULA and OWAS method), physiological stresses during operation (heart rate, energy expenditure) and environmental conditions (WBGT Index and CET) were assessed. It is seen from the study that energy required to carry one brick was greater in HM (1.34 kcal/brick) than in WBM (0.41 kcal/brick). Thus it can be said that the brick carrying by WBM is superior than carrying bricks directly on head. Further studies are suggested to find out the recommended safe load to be handled by the WBM. At present it causes localized muscle fatigue and workers take frequent rests in between the cycle.

AC49

AN ERGONOMIC ASSESSMENT OF BRICK MOLDING OPERATION IN INDIA AS AGAINST THE NUTRITIONAL STATUS OF THE MOLDERS.
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Kundu Amar, Research Scholar, IDC, IIT Bombay
Bandyopadhyay Bijeetri, Research Scholar, Presidency University, Kolkata
Ray Gaur.G., Professor, IDC, IIT Bombay

The main objective of this study was to identify the physiological demand for brick molding operation and assess the nutritional status of the laborers working in Brick kilns. During peak seasons, the brick molding workers have to work from 6 to 8 hrs in harsh climatic conditions to give maximum productivity apart from their involvement in mud preparation operation. Five couples (Husband and wife) between the age range of 17-30 years involved in the brick molding operation were studied. Attempt was also made to assess the nutritional anthropometry along with 24-hour dietary recall with an intention to observe the consequence of energy intake and output. It was observed that the mean heart rate (HR) responses for men and women involved in the brick molding activity was 130 (+5.33) and 126 (+7.76) b.min⁻¹ respectively. Though the brick molding activity was performed from afternoon till evening in squatting position, for majority of the men and women it was under light to moderately heavy activity based on classification of physiological workload for Indian workers. It was observed that the calculated daily energy expenditure for men and women were around 3412 kcal and 3275 kcal respectively. As per the 24-hour diet recall their average daily energy consumption of men and women were 2648.3 (+82.1) kcal.day⁻¹ and 2388 (+156.4) kcal.day⁻¹ respectively. This negative energy balance can effectively be observed in the nutritional anthropometry data irrespective of their genders. 40 % of men and women under this study were under the chronic energy deficiency as per their BMI. All subjects were ectomorphic. Ergonomics intervention on work method, new concept tool and better work posture with better with better nutritional status is suggested.

Keywords: Physiological Cost of Work. Heart Rate, Nutritional status
AC54
WORK POSTURE ANALYSIS OF BRICK MOULDING OPERATION IN BRICK KILN INDUSTRY AND DESIGN INTERVENTION.

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* Research Scholar, IDC, IIT Bombay
** Research Scholar, Presidency University, Kolkata
*** Project Assistant, IDC, IIT Bombay
****Professor, IDC, IIT Bombay

Brick manufacturing is an age old operation performed by the unorganized sectors in India. Moulding is an essential part of brick making process, where a lump of mud put into the mould and turned upside down with the help of three fingers of both hands so that the soft brick comes out of the mould for sun drying. The mould is again used for a new brick making. Moulding is basically a repetitive and continuous work performed in awkward squatting posture in which a load of around 6 kg is handled each time by hands minimum for 6 hrs a day. The sustained squatting posture created several musculoskeletal disorders in associated muscle & pain in different joint. This sustained posture hour after hour and for days after days is biomechanically very dangerous to health & needs to be changed immediately. The main aim of the study is to change the work posture from squatting to sitting-standing posture. Assessment of Work posture adopted during job (REBA, RULA, and OWAS method) was done. A user centred approach on moulders behaviour and understanding the issues were made on personal interview & observation method. Two different conceptual models of the workstation design were made by using solidworks CAD software based on anthropometric data of the moulders.

Keywords: Bricks, Bricks Moulding Activity, Work-posture assessment, Workstation design
Work Related Health Problems of Female Workers in the Brick Manufacturing Industries in West Bengal

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Ergonomics, Work Physiology and Occupational Health laboratory, Presidency University, Kolkata, India
\textsuperscript{1}Industrial Designing Center, IIT Mumbai, Powai, India

Brick manufacturing is an age old unorganised sectors in India. Off late, due to rapid urbanisation and spurt in real estate development, this has become one of the flourishing industries. But unfortunately the female workers here suffer a silent agony. Thus, a preliminary survey was done on 117 female workers engaged in six different brick fields of West Bengal. Physical parameters, such as body weight, height, BMI and psycho physiological parameters such as perceived exertion rating were studied during rest and while performing different tasks in the field. Moreover, REBA and RULA were done to study the postural status. Studies revealed that the workers suffer from musculo skeletal disorders and pain throughout the body working in an awkward posture, resulting in physiological, psychological and nutritional disorders etc. Majority of the workers suffer from chronic energy deficiency also. Over and above this, the environmental pollution was found to be very high. The total working age of the workers was very low. It was observed that situation required further investigation and immediate ergonomic intervention for humanising working environment.

Key words: women construction workers, posture, REBA, RULA, nutrition.
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This is to certify that the paper entitled
'Cardiovascular efficiency of brickfield women workers
around Kolkata, West Bengal'
authored by
Bijetri Bandyopadhyay, D Sen, G G Ray
presented in the International Ergonomics Conference-
'Humanizing Work and Work Environment 2014'
organized by Department of Design, Indian Institute
of Technology Guwahati, held during 3rd to 5th of
December, 2014.

Sougata Karmakar  Prof. Deb Kumar Chakrabarti
Conference Secretary  Conference Chair

Department of Design
Indian Institute of Technology Guwahati
भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
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the brick manufacturing industries in West Bengal."
in International Conference on Ergonomics and Human Factors held
at Dept. of Human Physiology with Community Health, Vidyasagar
umanizing Work and Work Environment
University, Midnapore on 4-6th December 2013.

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President, HWWE 2013
&
Vice-Chancellor
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&
Dept. Human Physiology
Vidyasagar University
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[Signature]

has participated/presented in the International Conference on Molecules to Systems Physiology: 100 Years Journey held at University of Calcutta on 21-23rd September 2011.

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Prof. T.K. Ghosh
Head, Department of Physiology
Chairman, ICMSP 100
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Centenary Celebration of the Department of Physiology
University of Calcutta

Theme: Ergonomics in Occupational Health

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